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# DEVELOPMENT DIGEST

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# DEVELOPMENT DIGEST

A quarterly journal of excerpts, summaries, and reprints of current materials on economic and social development

Gordon Donald, Editor; Pushpa Nand Schwartz, Associate Editor
Prepared by the NATIONAL PLANNING ASSOCIATION

for

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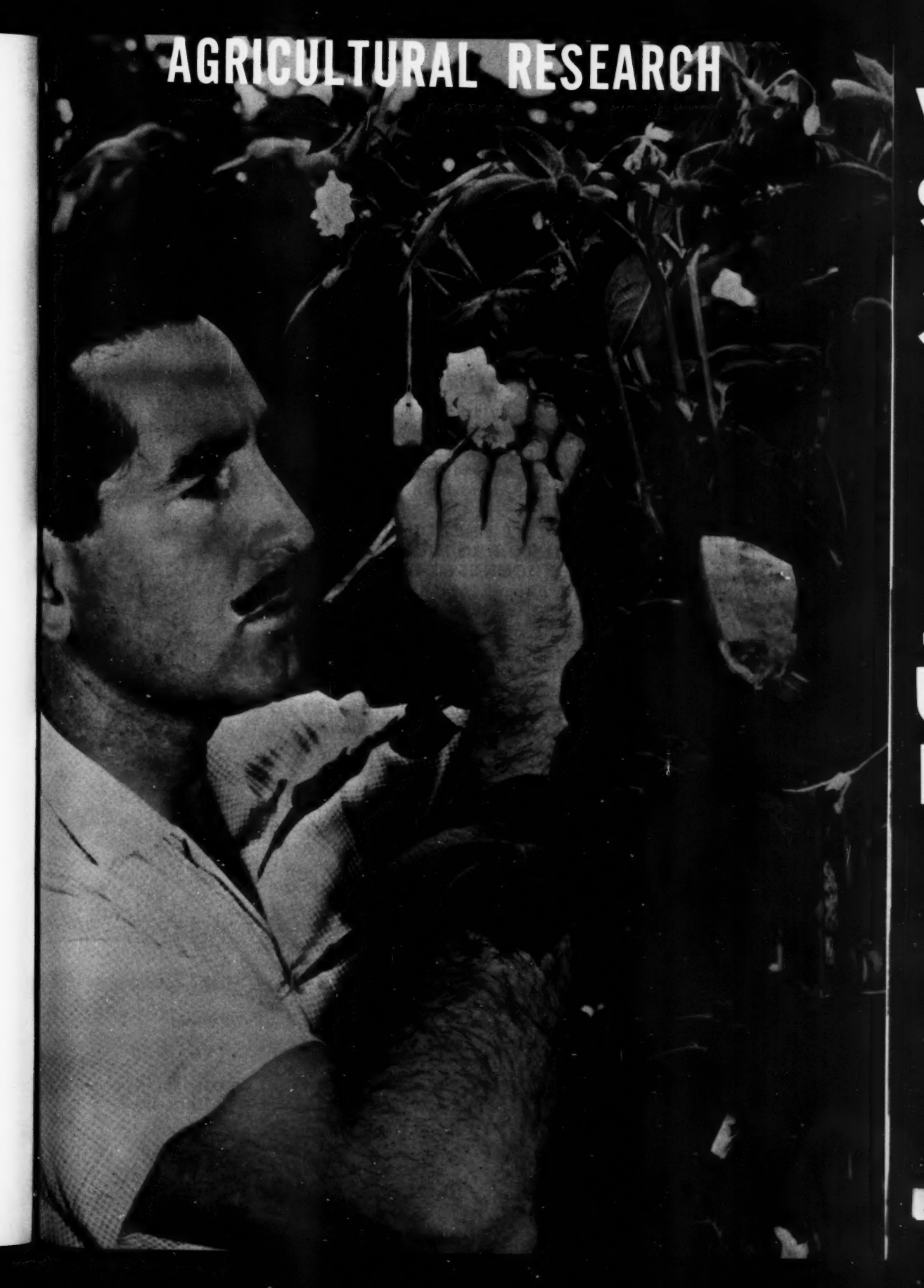
AGRICULTURAL RESEARCH

MEXICAN SCIENTIST BREEDING POTATO PLANT
EXPECTED TO PRODUCE HIGH YIELDS
[PHOTO: THE ROCKEFELLER FOUNDATION]

# Intensified Agriculture Through Research

Sterling Wortman

[Agricultural research is the major catalyst needed for the intensification of farm production. Not only new crop and animal varieties but the complexity of local conditions and crop adaptabilities must be explored, and especially in less-favored, hitherto neglected areas. The job is enormous, but it must be undertaken.]

Mankind now has the capability, given the will, to meet food needs for two or three decades and, in doing so, to stimulate widespread economic and social development in agrarian areas wherever agricultural productivity remains low and static. But realization of such comprehensive progress will require proper and massive investment of men and money, organization or reorientation of a great number of activities, and coordination of effort of national and international agencies far beyond that achieved in recent years.

Improvement in biological technology is the major catalyst in intensification of production. Every case known to me of rapid increase in average yield of any commodity in a developing (or developed) nation has been set in motion by development and demonstration by capable scientists of "complete packages" of technology, adapted to local conditions, which permitted substantial increases in absolute yield. By "complete packages" is meant high-yielding seed varieties, plus appropriate fertilizer-use techniques, plus adequate means of control of diseases and insect pests, plus necessary planting, cultivation, and irrigation techniques. In the case of animals, it means proper strain, nutrition, and management—all at once, with nothing important left

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out. As scientists have developed these improved systems, farmers have demonstrated their willingness to change. National leaders of some countries, on seeing the dramatic results, have been quick to mount nationwide production campaigns.

Investments in appropriate agricultural research and training can provide high returns. Zvi Griliches, for example, tells us that the accumulated past expenditures on hybrid corn research, private and public, as of 1955, came to $131 million; for each dollar, the social return came to $7 annually—a 700 percent rate of return. These and similar data should not be interpreted, however, as indicating that investment in agricultural research, per se, will be profitable. Much of the world's present agricultural research probably is not, because it is conducted by poorly trained people, or by capable people without adequate support, or by competent people who unfortunately are little concerned with urgent needs of the regions served. In such cases, research may be a useless economic burden to the nation, rather than a profitable investment. This must be changed. For high return to investment to be assured, research must: a) be directed against all technical barriers to productivity of a given commodity; b) be led by highly competent and dedicated scientists for sufficient years to obtain measurable results; c) be conducted by inter-disciplinary teams of scientists capable of simultaneously attacking all major problems; and d) be adequately supported with both men and money, so that results from central experiment stations can be widely tested and promoted on farms.

Because of lack of education, and often because of his remoteness from centers of scientific activity, the average farmer may be unaware of the availability of some or all of the technical and other inputs. Were he aware of them, he would probably find their complexity bewildering. In the less developed nations, extension services are usually manned by personnel who have limited education and are inexperienced in technical farming. Because of their limited access to new technology, they may be relatively useless in promoting intensive agriculture. If the uneducated farmer in remote areas is unable to put together the proper combinations of advanced practices for his own farm, and if the extension agents have neither the training nor the access to technology to do it, then who can? Must this farmer's participation in the increase of needed agricultural output await the day when he and others like him have greater education? The answer is an emphatic No. The research scientists—and only the research scientists—can remedy the situation, and they must.

Agrarian nations with inadequate food production face at least two problems: they must increase national totals to meet urgent needs and eliminate dependence upon other nations, and they must encourage production in geographical areas of greatest deficit and by large numbers of farmers with small and often remote landholdings. The first

objective is receiving serious attention by some nations with deficits. Naturally, efforts focus on maximum increases in minimum time. Generally, the large and quick increases are being obtained on better lands, where rainfall is good or irrigation possible, with those few crops for which adapted, high-yielding varieties exist, and through efforts of progressive farmers whose landholdings tend to be relatively large. But as national output increases, and as some farmers benefit while others do not, attention turns to the plight of the large numbers of uninvolved farmers with small landholdings, many of whom are in areas of local food deficit. Can they be benefited? In some cases, and one hopes in many, the answer is Yes.

There are a few dramatic new developments involving uneducated farmers with small landholdings. In El Salvador, some 8,000 such farmers in the hill regions are now realizing corn yields three or four times greater than ever before and are overcoming a very serious hunger problem, both through greater direct human consumption of cereals and by greater on-farm production of poultry and pork. Kenya has moved from a deficit to a self-sufficient situation with corn, largely because of increased yields of hybrid corn seeds on small farms. Other cases could be mentioned.

Behind each of these examples of progress has been a determined effort to bring science to bear on local problems. In each case, agricultural technology has been specifically and imaginatively tailored to local needs by public agencies. Behind each effort there have been men of vision and talented scientists. But the job remaining is immense: high-yielding technology must be developed for every crop and animal species, for every season, in every region of every nation; systems of supply of manufactured inputs and of transportation, marketing, and storage must be devised; institutional capabilities, national and international, must be created to initiate and then sustain accelerated economic and social progress. Outside agencies can assist, but most of the effort must be made by the individual nations, for only they can set the policies, establish or reorient the institutions, and train the farmers.

[Excerpted from "Intensified Agriculture Through Research," War on Hunger. Washington (D.C.): Agency for International Development, Vol. V, No. 4, April 1971, pp. 14-17.]

# Norman Borlaug, Pioneer in the Green Revolution

Don Paarlberg

[ The story of the Green Revolution begins in Mexico in 1944 when Norman Borlaug went to that country for the Rockefeller Foundation to improve its agriculture. There followed a chain of events, partly planned and partly the result of chance, that promises nothing less than the transformation of world agriculture. In 1970 Borlaug received a Nobel Peace Prize for his work. ]

The Mexico to which Borlaug came in 1944 was an agricultural country with three fourths of the people living on land cultivated with traditional methods. Corn yield per acre was eight bushels, compared with 28 bushels in the United States, and wheat yields were less than 12 bushels. Most farmers were illiterate. Per capita rural incomes were but a fraction of those in the cities. The numbers of people were increasing at a rate that would more than double the population in 25 years. As a consequence of population growth, the food supply was in jeopardy. Imports were rising, asserting a troublesome demand for limited foreign exchange.

Borlaug and the three other Americans with whom he started the work, coming in fresh with Foundation backing, had some enormous advantages. He was free from the political pressures which beset government efforts at agricultural development. He was not troubled by the professionalism that impedes university research. There was no compulsion to show a profit, as is the case in business enterprises. Perhaps most important, Borlaug was free from that handicap of the "short-term" assignment which keeps an agricultural scientist in a country just long enough to gain some understanding of the problem but not long enough to make a major contribution.

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He set up a program with these unique features: 1) Priorities were established, and adhered to. The number one priority was to improve wheat yields so as to feed hungry people. 2) No distinction was made between basic and applied science; emphasis was on whatever was needed to advance toward the program objectives. 3) Foreign career scientists were placed in charge and given long-term assignments. Young Mexicans were trained through internships and outstanding men were given advanced study with the purpose of preparing them to take over the program. Borlaug's idea was for the Foundation to "work itself out of a job."

Relations with the Mexican government were cordial from the first. The original venture was made at the request of government officials. Testing facilities were made available at the national agricultural college at Chapingo, just outside Mexico City. Cooperation with the government extension service began early and continued. One precaution was observed; the Mexican government must remain sufficiently distinct from the program so that failure of some program venture, if it occurred, would not implicate the government. And vice-versa! Only by keeping the relationship loose could the independence of the program be assured. Good relationships were also established with other agencies: the Ford Foundation, the Food and Agriculture Organization of the United Nations, the U.S. Department of Agriculture, and the U.S. land-grant colleges of which Borlaug was a product. But the same strict rule was followed: no ties that would restirct the autonomy of the operation.

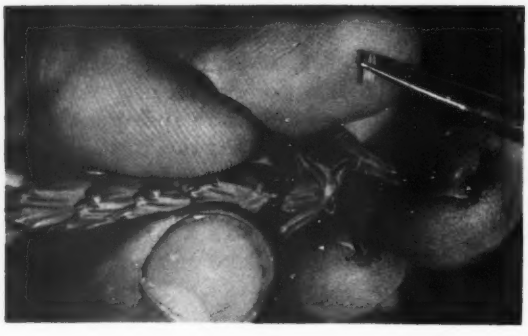
## Wheat, the Staff of Life

More people rely on wheat as their staple food than on any other crop except rice. Wheat is nutritious, palatable, low in cost, virtually free of taboos, storable, and in every way a superb weapon against hunger. If Borlaug could improve Mexican wheat, there was the chance that he might help wheat-eating people in the rest of the world. Mexico had to import 10 million bushels a year, more than half her supply. Wheat yields were abysmally low; technology was poor. Wheat varieties were numerous and enormously varied.

The first thing Borlaug did was to gather as many of the Mexican wheat varieties as possible, from various altitudes and latitudes. Altogether, some 8,500 individual head selections were made and were tested in many locations. The native Mexican wheats were generally susceptible to rust, a fungus disease that saps the vitality of the plant, clogs the passageways from root to blade, sucks out its moisture, and covers it with a growth that reduces the effective leaf surface. A field afflicted with the disease appears tarnished and "rusty," hence the name. The disease spreads by releasing tiny spores, brown, red, or yellow depending on the species, carried by the wind for hundreds of miles. One acre of well-rusted wheat may have as many as 50,000

billion of these spores. A severe case of rust can cut yields in half or even less. Only two out of Borlaug's wheat selections showed resistance to rust, and there is no assurance that a resistant variety will continue to be resistant. Rust, like wheat, may undergo mutation, and a new race may permit the rust to overcome the wheat's power of resistance.

Because of the importance of this disease, Borlaug decided to give first priority to bringing rust under control. So began the program to breed wheat for rust resistance. This involves crossing or hybridizing, an arranged marriage, the manipulation of germ plasm that permits the designing of plant varieties in a fashion similar to the designing of industrial products. The assumption in crossing is that the desired plant characteristics exist somewhere, perhaps masked or hidden, in some strain of wheat. The objective is to find them, lift them out, and combine them with other desired features in a new useful form. The crossing required to achieve this result is a delicate operation, performed with tweezers and magnifying glass.



Extracting wheat grains for breeding. [Photo: U.S. Agency for International Development]

The wheat that results from the first planting of a cross may look like either of the parents, or may be intermediate and look like a new variety, depending on its inheritance. When its seed is planted to produce second-generation plants, many different types may appear. No two plants are identical in the second generation. The plant breeder selects the superior ones, using as his criteria such attributes as disease resistance, yield, baking quality, drought tolerance, maturity, standing ability and so on. Less desirable plants are discarded. The plant breeder keeps selecting and discarding for about six or eight generations, by which time the new variety takes on considerable uniformity. It is then increased and tested on a larger scale in various regions. The whole process takes about 10 years; if two crops a year are grown, the necessary time can be reduced by half.

Once the process of selecting and discarding has been completed, the resulting hybrid remains fixed in its genetic composition. While the crossing of wheat is difficult and delicate, the lasting results make multiplication of the new variety both rapid and low in cost. It was this character that made possible the speedy expansion of improved wheats throughout Mexico and eventually overseas. Over a period of 20 years,

Borlaug and his associates made more than 30,000 of these wheat crosses and tested the results. The choice of which to retain and which to discard is in part a matter of scientific testing and in part intuition. The two Mexican lines that had shown resistance to rust were crossed with the more promising of the other lines. In addition, there were crosses with rust-resistant wheat introduced from the United States, from Kenya, from Australia, and from Morocco. Some of these crosses produced wheat that had a fairly high degree of rust resistance.

Borlaug came to the conclusion that his improved wheat should not be highly specific in its adaptation. Mexico has a multitude of microclimates and ecological conditions. Variations in moisture, temperature, latitude, altitude, fertility and tillage practices are very great. To try to tailor a specific and different wheat for each particular circumstance would be an impossible task. So Borlaug set about to develop a limited number of wheat varieties with general rather than specific adaptation. It was this approach that permitted the rapid spread of his wheat not only within Mexico but outside the country, from Morocco to India.

Another favorable result from a mixture of good planning and good fortune was the development of wheat varieties that were non-photoperiod-sensitive, or light-insensitive. Borlaug bred photoperiod-sensitivity out of his wheats. He came up with wheats that utilize the same number of days to maturity regardless of whether the hours of daylight are lengthening or becoming shorter. This was an enormous gain. If wheat is light-insensitive and if moisture and temperature permit, a farmer in or near the tropics perhaps can get two crops a year, which nature never intended. And the wheat will be adapted within a latitude of perhaps 5,000 miles instead of 500.

Borlaug and his team worked hard; in a single season they made 2,000 to 6,000 individual crosses. "Some of these kernels may be gold nuggets," said Borlaug. "Find them!" In 20 years of work they created and distributed some 75 new varieties, of which four subsequently comprised the bulk of the wheat grown in Mexico. The wheat-breeding techniques used in Mexico were not designed by Borlaug. What was unique was the execution of the plan, the adherence to the goal, the depth of his commitment, and the continuity of personnel.

By 1951 it began to look as if the battle against wheat rust had been won. Then suddenly appeared race 15B, a type of rust previously of little importance, which spread rapidly throughout Mexico, the United States, and Canada. Race 15B was deadly to two of Borlaug's four varieties, but the other two came through well. Reliance was shifted to these varieties and the new threat passed. In 1953 another variant of rust, race 139, attacked the remaining two of his established varie-

ties. A series of new crosses, using lines carried in the wheat nursery, produced the resistant Chapingo 52, Chapingo 53, Bajio, and Mexe. These resisted the new rust and provided the basis for his successful updated varieties.

Now that this new wheat was developed, how would he get the farmers to accept it? Four years after his work began, Borlaug showed his results to the neighboring farmers. Five farmers showed up for his first field day at his test plots in the Valle del Yaqui in Sonora. Within three years there were hundreds of farmers attending his field days, and after eight years there were thousands, coming from all parts of Sonora and three neighboring states. These were the farmers said by some to be apathetic and disinclined to change, but in fact the farmers forced Borlaug to release his wheat before he had intended when he saw them picking the heads off wheat plants in his test plots.

## The Giant Dwarf

By 1957, thirteen years after his work began, Borlaug was able to say that he had the rust problem under control. A number of new lines had been released; 70 percent of area cultivated to wheat was seeded to these new varieties. The national average yield had been increased from 11.5 to 20 bushels per acre. This was unprecedented and unquestionable success.

But yields were still low. Soil fertility was limited and the capacity of his wheat varieties to take up soil nutrients was likewise limited. Soil fertility could be increased with fertilizer. But Borlaug's wheats responded by growing tall and lodging, i.e., falling flat with rain and wind rather than producing more grain. A small application of fertilizer helped some, but beyond that point, the more fertilizer the lower the yield. This was true of all the Mexican varieties, which were naturally slender and inclined to be tall. As in most parts of the world, farmers had traditionally selected seed from plants with the highly visible attribute of tallness, associating this—often incorrectly—with vigor and productivity.

What was needed was germ plasm, from somewhere, that would permit the wheat to assimilate a large amount of soil nutrients and convert these nutrients to grain, standing stiff and erect in doing so. These attributes had to be capable of being incorporated into his adapted rust-resistant Mexican wheats. He had no such germ plasm; evidently he had to go outside of Mexico to get germ plasm capable of high nutrient intake and high yield.

From Japan came this last major component of Borlaug's miracle wheat. The Japanese farmers were growing a number of remarkably stiff, short-stemmed wheat varieties. When heavily fertilized, these

varieties stayed erect and gave good yields. These short-stemmed Norin wheats of Japan have as many leaves and, hence, as big a manufacturing surface per stem as the other wheats. The difference is that they have shorter intervals between the leaves. They waste less effort in erecting an unproductive stalk, and they have many more stems per plant. Furthermore, and extremely important, the Norin wheats have the capacity to take up large amounts of soil nutrients and convert them to grain.

Sixteen varieties of Norin were made available to American wheat breeders in 1947/48. Orville A. Vogel, a wheat breeder of the U. S. Department of Agriculture and the first to recognize their worth, discovered that the Norin wheats had many faults under American conditions. Vogel went to work on these defects, and eventually overcame them; he found that the short-strawed character of Norin 10 was readily transferred to the offspring when crossed with other varieties. Borlaug obtained some of the early crosses and breeding lines from Vogel in 1953, crossed Vogel's wheats with his Mexican varieties, and obtained the desired adaptation: disease resistance and short straw. The increased yield potential of the new dwarf wheat was due not only to its non-lodging characteristic but also to its greater number of stems, the greater number of grains per head, and its better grain-filling qualities. Furthermore, since the varieties he developed were non-photoperiod-sensitive, they had wide adaptability and were capable of being grown in most of the tropical and sub-tropical wheat-producing countries of the world. Growing two crops a year, Borlaug had two varieties, Pictic 62 and Penjama 62, ready for release by 1961, eight years after he first received the parent stock.

Optimum nitrogen application for the old wheats had been about 40 pounds per acre; the new wheats made efficient use of 120 pounds. Increased amounts of phosphorous and potash were also needed, as were some of the minor elements. Balancing the diet for these new wheats required an immense amount of research in soil fertility and plant response, which Borlaug and his colleagues readily incorporated into the work of the Rockefeller project, along with pathology and genetics. The new wheats were so prolific that all kinds of undertakings, previously unprofitable, became paying practices: weed control, the use of insecticides, and additional irrigation. Borlaug moved into these areas with his research.

Once the practices were orchestrated the yields of these wheats were phenomenal. Better farmers, using improved methods, were able to get yields as high as 105 bushels per acre, two and a half times as high as top yields with Borlaug's earlier varieties. In 1965, Borlaug could say, "The impact of these varieties has been so great that in four years they have taken over 95 percent of the area cultivated to wheat in Mexico." The wheat was so attractive to farmers that virtually all of

the first crop and much of the second was used for seed. National average wheat yields per acre, which had almost doubled from 1943 to 1957, increased another 50 percent by 1963. Eleven and a half bushels per acre, national average, in 1943; 30 bushels per acre in 1963! From a wheat deficit of 10 million bushels, half her needs in 1943, Mexico now provided the wheat for a larger population and fed them better.

## The Breakthrough

Agricultural development people throughout the world noted the Mexican success and a parade of visitors came to the project. An International Rice Research Institute, modeled on the Mexican wheat experience, was set up in the Philippines. There were several things about this breakthrough that make it special: It came in the hungry part of the world, not in those countries already surfeited with agricultural output. It came in the tropics, which had long been in agricultural torpor, not in the temperate climates where change was already rapid. It produced new knowledge and technology that could be used by farmers on small tracts of land, rather than being, like many technological changes, adaptable only on large farms.

Closely built into his wheat research, Borlaug had a trainee program resembling an apprenticeship arrangement. Over the years, some 100 young scientists from 22 nations participated in his program, learned his methods and absorbed some of his enthusiasm. They returned to their countries, often carrying the new wheat varieties with them. These were "the wheat apostles," who laid the groundwork for the later rapid expansion of the Mexican wheats.

In India and Pakistan, agricultural practices had changed but little for centuries, as in Mexico. The two countries were experiencing more than their share of the population explosion, and had been barely meeting their food needs by increasing imports of American PL-480 wheat—a policy that could not continue idenfinitely. In 1963, government officials of India and Pakistan invited Borlaug to visit their countries. At Lyallpur, Pakistan, he found a number of wheats from Mexico—brought to Asia by two Pakistani trainees who had been with him in Mexico. These two young men, Manzur Bajwa and Noor M. Chaudhry, had grown and observed these wheats at Lyallpur since 1961. The wheats looked rather ordinary; the research administrators had not permitted the rates of fertilization and the cultural practices suited to them, insisting on the standardized treatment. But the young men had purposely mislabeled one of Borlaug's wheats, planted it in an obscure corner of the test plot, and applied 120 pounds of nitrogen instead of the authorized 40 pounds. The result was phenomenal.

As soon as the performance of the Mexican wheat was noted, Pakistan ordered 200 kilograms and India 300, sent by air. In 1964 these wheats

were planted, experimentally, in various locations in both countries. Despite poor fertility practices, results were good. A plan was developed: half the wheat would go for commercial increase to make more seed available the following year; the other half would go for demonstrations, planted in small plots by hundreds of farmers. Breeding work would go forward at the experimental farms, and there would be a step-up in the training of young scientists. India ordered 250 metric tons from Mexico in 1965 and Pakistan 350. This was to be seed stock from Mexican commercial fields, not from test plots. But as a result of improper fumigation and handling, much of the wheat had lost its ability to sprout. The Indians and Pakistanis planted the wheat at regular rates. It came up thin on the ground, an extremely poor stand, 7,000 acres in India and 10,000 in Pakistan. But each plant tillered out, sending up many stems so that at maturity it seemed almost a full stand. Amazingly, about 80 percent of the research work done in Mexico proved to be directly transferrable to Asia.

For the 1966/67 crop, India ordered 18,000 metric tons of seed wheat from Mexico, the equivalent of two average shiploads. Together with seed from their own production, this was enough to plant 700,000 acres. The Pakistanis had enough for 600,000 acres. This was the year of the great drought on the Indian subcontinent, but the Mexican wheats did well. Under farm conditions, with proper cultural practices, they outyielded the native wheats by a factor of 2 or 3 or 4, sometimes even more. Standing three feet tall instead of four or five, they took up enormous amounts of soil nutrients and still stood erect.

Then a great debate arose in India and in Pakistan. The Mexican wheats had looked very good. Should a full and firm commitment be made to these wheats? The decision lay with the government administrators, who consulted the farmers, the extension service, the production scientists, the economists, and the sociologists. Counsel was divided. The farmers wanted the wheat, but many of the scientists were dubious about staking so much on a wheat so new, subjected to such limited testing. Suppose there should be an outbreak of some plant disease to which the new wheats were susceptible, and the whole crop were lost? For a nation on the threshold of hunger, the margin for experimentation was too thin. The cultural practices recommended for the Mexican wheat were far beyond the experience of Asia. Where would the necessary fertilizer come from? Could farmers be taught to fertilize and irrigate properly? The Mexican wheats produced relatively little straw; how would the bullocks be fed? The color of the wheat was red, while the Indians preferred white. Baking qualities were not the preferred ones. With abundant supplies, the price would be driven down. And so on.

In the end, the victory went to those who favored the Mexican wheats. Pakistan imported 40,000 metric tons in 1967, enough, with the seed they themselves had grown, to plant three million acres. The pro-

motional program was tremendous. There were demonstration plots all over the land, some 30,000 or 40,000 altogether, contrasting the native with the Mexican wheats. Weather was good and yields from these wheats were heavy. In Pakistan the new wheats occupied 20 percent of the total wheat area and produced 42 percent of the total crop. In India the corresponding figures were 18 percent and 36 percent. The total production of wheat in Pakistan exceeded the previous record by approximately one third, bringing self-sufficiency for the first time in years. Further expansion of acreage in these wheats occurred in 1968/69 when India seeded 13 million acres and Pakistan 7 million. Mexican wheat varieties are grown on an area 15 times as great as the entire area sown to wheat in Mexico only six years after the first samples, measured in grams, were received for trial.

The Mexican wheats were a stimulus for other crops. Almost concurrently with their adoption came the spread of the new "miracle rice," IR-8, produced at the International Rice Research Institute in the Philippines. Like the new wheats, the new rice is short-strawed, capable of standing erect when heavily fertilized, a voracious feeder, widely adapted. The techniques for developing the miracle rice were modeled on those used by Borlaug on wheat. These two cereal grains are the backbone of the world's food supply. Both have been immensely improved and together they have touched off a transformation in the growing of crops, a "green revolution."

[Excerpted from Norman Borlaug—Hunger Fighter. Washington (D.C.): Foreign Economic Development Service, U.S. Department of Agriculture, cooperating with the U.S. Agency for International Development, PA 969, December 1970, pp. 1-17.]

Dr. John Gibler, former Borlaug associate, extracting rust from wheat by suction for new experiments using innoculation to find resistant varieties. [Photo: U.S. Agency for International Development]

# The International Institute of Tropical Agriculture, Nigeria

Herbert R. Albrecht

[A new international research center has been established in Nigeria in which priority is given to problems of food growing in tropical areas now limited to bush-fallow cultivation, and to training African scientists. Its work will complement that of a similar center in Colombia emphasizing livestock problems in the tropics.]

The tropics are the largest underdeveloped resource to which the world may look for the increased agricultural production required to meet the food and fiber needs of its rapidly expanding population. On the land that is cultivated yields are generally low, and vast areas remain unused. Yet most of the world's hungry people live in the tropics—and a majority of the people who live there are hungry. The explanation of this paradox is that the potentials for food production in the tropics cannot be realized within the limits of presently available knowledge and technologies of agricultural production and the small number of trained agricultural specialists in the countries of the tropical regions.

The problems of agricultural production, especially in the low hot tropics, appear to be particularly intractable. Cropping systems involving the annual food crops have not yet been developed capable of maintaining high levels of sustained productivity. There is still no replacement for the system of bush-fallow. Few improved varieties of food crops adapted to the humid tropics are available. Diseases, insect pests, nematodes (thread-like worms) and vertebrate pests take a heavy toll of crop and animal production and of stored crops, and

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control measures have generally not been developed. With unimproved varieties and heavy losses from plant pests, the use of commercial fertilizers usually is uneconomical. The farmer of the tropics is locked into a primitive, unproductive system. Only infusions of new and strikingly better technologies of production, which must come from research, will transform the traditional to modern agriculture and unlock the food potentials of the tropics.

The Rockefeller and Ford Foundations began discussions with the Government of Nigeria in 1963 concerning the possible establishment of a major international research and training center, modeled on the International Rice Research Institute (IRRI) in the Philippines, to focus on finding solutions to these problems. The International Institute of Tropical Agriculture (IITA) was formally organized on July 11, 1968, as an autonomous, non-profit, tax-exempt Nigerian corporation. Building construction and recruitment of staff began in the autumn of 1968. At present about 25 scientists are at work, and by next year the senior professional staff is expected to number 32 with 50-75 trainees, about 100 research assistants and scholars, and 100-120 technicians and clerks. As a matter of policy the senior scientific staff will be drawn from all parts of the world. Most of the research assistants and scholars are expected to come from African and other tropical countries. The Government of Nigeria has provided 2,200 acres of land for the use of the Institute north of Ibadan, adjacent to the campus of the University of Ibadan. The University has a Faculty of Agriculture with a modern physical plant, good library facilities, a teaching staff of more then 300 and approximately 3,000 students. Moor Plantation, one of the largest agricultural research centers in Africa, is located nearby. Thus far the core support for the Institute's operations has been provided by The Ford and Rockefeller Foundations, the Canadian International Development Agency and the U.S. Agency for International Development (AID).

Aims

The broad purposes of IITA are to increase the yields and improve the quality of food crops in the tropics and to develop soil and crop management practices that will make possible a stable, permanent and productive agriculture. Initial emphasis will be on the hot, humid tropics, but attention to developments in the dry forested and savannah (treeless plain) areas of the hot, monsoonal tropics is not excluded. IITA will seek to accomplish its purposes through sharply focused, production-oriented research on major problems that impede progress in increasing food production in the tropics; training programs for research and production specialists; fostering development of networks of cooperative research institutions; providing assistance in the development of national research, extension and production programs; maintaining germ plasm banks of important tropical food

crops; and maintaining a library, documentation and information service relative to pertinent aspects of tropical agriculture.

Although IITA's programs will, because of its location, be particularly applicable to the tropical belt across Africa, they are also expected to have an important impact on food crop agriculture in the Asian and Latin American hot tropics as well. The research program will have two major thrusts:

1. The development of economically viable cropping and soil management systems for the tropics that will make it possible to replace bush-fallow with continuous cropping.

2. The development of improved production technology, including methods of plant protection and of storage, that will increase yields and improve the nutritional quality of important food crops.

IITA shares with the Centro Internacional de Agricultura Tropical (CIAT) in Colombia responsibilities for research, training and other activities pertinent to the improvement of tropical agriculture. The specific activities of the two institutes will be complementary rather than duplicative. IITA, while concentrating on various aspects of food crop agriculture, may also serve as a center for testing and extending CIAT's findings on animal husbandry to African pastures and livestock. Conversely, CIAT, while concentrating on animal production—particularly beef cattle and the forage crop and soil science research relevant to producing feed for livestock—may serve as the focal point for testing and extending to Latin America IITA's findings on the production of tropical food crops.

Soil and Crop Management

With presently available knowledge and technologies, the management of the old residual soils of the tropics for sustained high levels of production of annual food crops of good nutritional quality is difficult if not impossible. These soils are generally lateritic, deficient in plant nutrient elements and divalent bases, they have a low pH and are high in aluminium and iron. High year-round temperatures cause extremely rapid chemical and bacterial decomposition of minerals and organic matter. The soils are subjected during the rainy season to heavy run-off, with leaching and erosion especially serious when the soils are not covered with vegetation. Yields decline and structure deteriorates rapidly under cultivation.

The shifting cultivation or bush-fallow system, which evolved over the centuries throughout the tropics, has enabled cultivators to obtain a relatively stable level of food production from their soils without destroying them, but it is not adapted to meeting the needs of a rapidly

growing population. With it, the land produces crops only 3-5 years out of 15-25 years and crop yields, although fairly consistent, are low by modern standards. Population pressures in some areas—West Africa, for example—are already causing the rotation to be shortened by reducing the time in bush-fallow from 15-25 years to as little as 3-4 years with serious effects on productivity.

Despite research efforts to date, no system of food crop production has yet been developed which is a satisfactory replacement for the bush-fallow system. The solution must come from intensive multidisciplinary research involving agronomists, soil fertility specialists, soil chemists, soil physicists, soil microbiologists, soil management experts and economists. Studies will include crop rotations, crop sequences, cultural practices, management of crop residues and other means for maintaining vegetative cover of the soil for a maximum percentage of the total cropping cycle and for preservation and renewal of the soil organic matter. Research will be conducted on applications of various amounts, kinds and formulations of plant nutrient elements and other soil amendments in relation to sustained crop productivity and the chemical, physical and microbiological characteristics of the soil. Field investigations will also be made into soil conservation, irrigation, multiple cropping, inter-cropping, weed control and other factors related to increasing and maintaining soil and crop productivity.

Crop Improvement and Plant Protection

The major food crops of the humid tropics include the cereals, principally maize, rice and sorghum; the protein-rich grain legume and oil seed crops of which cowpeas and soya beans appear at this time to be among the more promising; the root crops, including cassava, yams and sweet potatoes; and a number of vegetable crops.

Maize and rice improvement programs will be initiated at the outset at IITA in close cooperation with the International Maize and Wheat Improvement Center (CIMMYT) and IRRI. The latter institutes will be looked to for basic germ plasm, improved genetic combinations, advanced breeding materials and breeding methods for these crops. IITA should thus be able to make rapid progress in developing improved varieties and hybrids of maize and rice for the African tropics. If a sorghum improvement program is initiated it will draw on resources of the AID-supported programs at Ahmadu Bello University, the East African Agriculture and Forestry Research Organization, and the Indian Agricultural Program of the Rockefeller Foundation.

With oil seeds, grain legumes and root crops experimentation is necessary to determine which individual crops are potentially most important in terms of productivity, balanced human nutrition, useful-

ness in cropping systems and economic returns. An important aspect of the early research program at IITA will be this determination of relative importance. It is anticipated, however, that cowpeas, soya beans, cassava and possibly sweet potatoes will have a continuing or increasingly important role in tropical food production. IITA will proceed immediately with programs of varietal improvement for these crops. World germ plasm resources will be systematically assembled, evaluated and maintained. Testing programs will identify existing varieties, if any, that are sufficiently superior to warrant immediate increase and use. Hybridization and selection programs, designed to produce further varietal improvement, will be initiated. Emphasis will be on increasing yields, improving nutritional quality and achieving low costs of production per unit of product.

Insect pests, plant nematodes and diseases caused by fungi, viruses and bacteria currently take a heavy toll of food crop production in the tropics. Losses in storage are also great. Research workers at IITA will, therefore, concern themselves with both pre- and post-harvest crop protection. Multi-disciplinary research programs will include development of cultural, chemical and biological methods of control aimed at reducing losses in the field and in storage.

Livestock and Forage Crops

One possible way of eliminating bush-fallow in the humid tropics without undue risk of erosion is to replace the bush with planted forages — perennial legumes and possibly perennial grasses — for use as pasture or harvested feed for ruminant livestock. This will require a program on forage crop and livestock — principally cattle — management in the humid tropics. In the broad belt of savannah and derived savannah that lies north of the humid tropics of Africa are vast areas best suited for range livestock production — primarily beef cattle and sheep. Before the production potentials of these areas can be realized, however, there must be extensive research on animal health, nutrition and physiology and on breed improvement and livestock management. Research is also required to develop technologies for managing and improving tropical range lands for maximum sustainable production on an economic basis.

IITA's programs of livestock and forage improvement in the humid tropics and savannah will, as mentioned earlier, be closely coordinated with CIAT's programs in these fields. CIAT will serve as the principal research center providing basic information and technologies and general scientific guidance. IITA also expects to cooperate extensively, of course, with animal research stations located in Africa.

## Agricultural Engineering

Agricultural engineers on IITA's staff will undertake research on power sources, agricultural implements, planting, tillage and harvesting methods, irrigation, soil conservation, applications of pesticides, and structures and methods for the storage and preservation of crops. These efforts will be in cooperation with other scientists, including agronomists, soil scientists, plant protection specialists and economists.

## Training Programs

Research centers such as IITA, IRRI, CIMMYT and CIAT are not a substitute for effective national research organizations in newly developing countries. Agriculture is a biological industry carried on in an almost infinite variety of local environments. Soils differ, topography differs, climates differ, insects and plant diseases differ and markets differ from region to region, from area to area and often from community to community. Furthermore, some of the factors influencing patterns of agricultural production change over the years. All this means that packages of improved production practices must be developed to fit a wide variety of environmental and economic situations, and that adjustments in these packages must continually be made as circumstances change. This in turn requires networks of research institutions and experimental stations continually engaged in developing and testing improved production technology.

IITA will assist in the development of such networks in three ways:

1. by helping train research scientists for the staffs of agricultural research organizations in newly developing countries in the tropics and subtropics;

2. by sponsoring from time to time symposia, seminars and workshops on various aspects of tropical agriculture relating to food crops; and

3. by providing library, documentation and information services with special emphasis on soil and crop management and the production of food crops in the tropics.

Trainees who expect to return to their home countries to engage in agricultural research will be assigned to work with senior scientists at IITA for periods of time ranging from a few months to three years to receive intensive training in research techniques and procedures. Arrangements are being discussed with the University of Ibadan and other African, European and American universities which would permit some of these trainees to use research done at IITA in partial

fulfillment of requirements for the M.S. or Ph.D. degrees. Experience at CIMMYT and IRRI indicates that intensive training for even relatively short periods of time in an institution with a sharply focused, production-oriented research program can be extremely useful in increasing the research competence and productivity of young agricultural scientists from newly developing countries.

If improved, science-based production technology is to make significant contributions to development in newly developed countries, there must be close and effective linkage between research organizations on the one hand and farmers on the other. Farmers must be instructed in the use of new technology, and problems which arise in the field must be referred back to appropriate research centers for solutions. A weak link in the extension services of most newly developing countries is a shortage, or complete lack, of people with sufficient technical and production knowledge to diagnose correctly the more common production problems as they appear in farmers' fields and recommend appropriate action. Few extension workers at the village level in newly developing countries are qualified to perform these functions and this is likely to be the case for many years to come.

What is needed are cadres of production specialists trained to perform the functions described above and thus serve as a communications link between village level workers and farmers on the one hand and research scientists on the other. It clearly will not be possible for IITA to train the numbers of such persons that will be needed in tropical Africa and elsewhere, but IITA can help develop effective methods of training and assist in "training the trainers" for extension services in newly developing countries.

[Excerpted from "Problems of Tropical Agriculture: International Work on Solutions," Standard Bank Review. London: Standard Bank Ltd., May 1970, pp. 2-7.]

# Legume Production – Status and Potential

P. H. van Schaik

[Legumes have been neglected in research by comparison with grains, but they are an important protein source for people dependent on a cereal diet. Research aimed at increasing their productivity would provide a substantial nutritional pay-off in many developing countries where they are already familiar foods.]

The family Leguminosae is the second largest family of seed plants, with about 600 genera and 13,000 species. Some ten or twelve crop species are of economic importance, including beans, peas, soybeans and peanuts or groundnuts, and others which are important in the tropics and subtropics such as chickpeas, pigeon peas, mungbeans, urd beans, cowpeas, lentils, and broad beans. Vegetable sources supply some 71 percent of human protein intake according to Food and Agriculture Organization of the United Nations (FAO) estimates; of this 71 percent, pulses, oilseeds, and nuts account for 13 and cereal grains for 50 percent. Total world acreage and production of the major food legume crops in comparison to wheat and rice are shown in Table 1.

In the developed countries legumes are now a rather insignificant part of the diet, but in developing countries which are short of protein they make a greater nutritional contribution. In countries where starchy roots and fruits such as cassava, yams, sweet potatoes and bananas replace cereals as staple foods, legumes assume a special importance in providing needed protein. Some of the advantages of food legumes are: 1) They are high in total protein content, 18-25 percent (see also Table 2). 2) They have a good essential amino acid balance—high in lysine but limited in sulfur amino

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Table 1: World Production and Acreage

| | Area (000 hectares) | | Production (000 metric tons) | |
|---|---|---|---|---|
| Total Legumes | 115,257 | | 97,776 | |
| Pulses | | 63,089 | | 39,614 |
| Soybeans | | 33,672 | | 40,764 |
| Peanuts | | 18,496 | | 17,398 |
| Wheat | 221,900 | | 298,000 | |
| Rice (paddy) | 128,800 | | 275,900 | |

SOURCE: 1968 Production Yearbook, FAO.

acids, methionine and cystine. This makes them particularly valuable as supplements to cereal diets. 3) They are grown throughout the world and are commonly consumed at all economic levels. They present no problems of acceptance as new foods, nor in overcoming religious taboos.

Table 2: Yield of Protein of Different Crops

| | Protein, kilograms per hectare |
|---|---|
| Rice | 42.3 |
| Sorghum | 33.0 |
| Maize | 73.0 |
| Sweet Potato | 36.5 |
| Legumes | |
| Beans (Chickpea or Cowpea) | 88.8 |
| Soybeans | 129.0 |
| Groundnut | 113.4 |

SOURCE: Brock, J. F., and Autret, M., Kwashiorkor in Africa, Rome: FAO, 1952 (mimeo). Figures based on African crops 1946-48.

## Need for Research

Legumes have not enjoyed the prestige or economic importance of staple cereals and the crops widely grown for commerce, as in plantations. They have received little attention in improvement programs, partly because they were generally limited in use to rural people whose needs were not considered seriously by national governments or colonial powers. In addition, they are difficult crops for farmers to grow well, and difficult for a researcher to work with, because of

the numerous hazards encountered during the growing season. Only a few species have been of importance for research in the developed world, from which the impetus of development has generally come, and there have been only scattered, uncoordinated research efforts on legumes in the developing world until recently. There is a great deal we do not know about these crops, and it is impossible as yet to come up with a package of practices which will assure a farmer a good harvest.

A multi-discipline research program aimed at finding ways to improve production of the major food legume crops in Asia was undertaken in Iran and India in 1965 under sponsorship of U. S. AID (Agency for International Development) and U. S. Department of Agriculture's Agricultural Research Service. Some extensive germ plasm collections of a few major food legume crops have been assembled in recent years. Although they have been initially screened, they need to be thoroughly evaluated for a wide range of characteristics so that parents can be selected for use in crosses with wide genetic diversity for development of superior varieties. In general the genetic base of existing breeding programs on these crops has been much too narrow. From these collections nine new and improved varieties of beans, cowpeas, mungbeans, and chickpeas were selected in Iran and recommended to the government for release. The Indian Agricultural Research Institute released a variety of mungbeans—Pusa Baisakhi—which can yield some 1,000 kg. per hectare in a 70-75 day period from April to June, between the harvest of wheat and the sowing of summer monsoon crops, when normally no crops are produced. Other research institutions in India and in several other countries are beginning to make use of these collections.

Legumes are extremely susceptible to a wide range of diseases. The causal organisms of many of these have never been identified, even though the diseases have occurred for many years. For others the causes are known but no solutions have been found. In chickpeas, for example, the blight caused by a fungus, Ascochyta rabiei, has severely limited production in India and Pakistan. Until recently the search for resistance was limited to screening of local types under natural conditions, which yielded few worthwhile results. In the past few years we have learned that there are several races of the fungus involved, and a good genetic resistance was identified in a variety from Israel. This resistant type is now being used by breeders as a parent in making crosses to incorporate the disease resistance into agronomically more attractive new varieties. Control of this disease alone could increase yields of the 3.5 to 4 million hectares of chickpeas in the Punjab area of India anywhere from 5 to 50 percent.

Insects cause great damage to legume crops, particularly during the hot, humid rainy season in the tropics. Although chemical controls are available for most insects, the application of insecticides

is difficult for peasant farmers and resistance to insect attack must be found and incorporated in new varieties. Only a start has been made in this work, but indications are that resistance can be found to several insects. Chickpea and lentil lines have been identified with resistance to bruchids, a group of pod and seed boring insects whose damage to various food legume crops has been estimated as high as 40 percent. Cowpea lines with considerable field tolerance to several leaf chewing insects such as flea beetles, leaf miners and jassids have been found in preliminary field trials. A great deal of microbiological research is required before successful exploitation of the nitrogen fixation capability of legumes can be practiced as a soil fertility factor. Little is known about bacterial interactions and competition under natural field conditions in tropical soils.

There is little doubt that food legume crops respond to good crop management practices such as proper land preparation, planting in rows, irrigation, weed control, insect control, fertilizer application, etc. What information there is in the literature shows that improved practices could make a sizable contribution towards better production. For example, yield trials in Iran with selections from local cultivars but with good management of irrigation, fertilizer, pest control, and proper plant populations have given yields as high as 400 percent of average farm yields.

To find answers to the numerous production problems, research must be undertaken to develop new varieties with high-yield potential, resistant to diseases and insects, responsive to fertilizer and other management and input factors. It will also be necessary to launch extension education programs to educate farmers to grow these crops with the same care and on the same basis as they now do cereal grains. The food legumes must be removed from their present status of "second rate" crops.

There are no serious adaptation problems. At least one food legume crop is grown commonly in each major protein-deficient area, and there is little need to try to introduce new crops in new areas. Greater consumption can be brought about simply by greater production. Programs to increase supplies of legumes will initially depend not so much on devoting more land to their cultivation as on achieving higher yields. In countries where pulses are accepted and eaten as a common food, as in many Asian and Latin American countries, a greater demand probably exists than present production can satisfy.

## Increasing the Use of Food Legumes for Supplying Protein

We know that the pulses are high protein crops and they are generally high in lysine (with the exception of peanuts) and low in the sulfur amino acids. But no large scale, systematic screenings of germ

plasm have been conducted to determine the genetic range in total protein or amino acids. A preliminary screening in India of some 1,800 pigeon pea germ plasm lines for protein content showed a range from 18 to 32 percent, which seems to indicate considerable improvement potential. To my knowledge no breeding work has been or is being conducted anywhere towards improvement of total protein or of the limiting amino acids. Flatus producing factors, toxins, and anti-metabolites are of considerable importance in food legumes, but here again the information available is not sufficiently specific and no screening programs have been conducted to provide information needed for improvement programs.

Soybeans and groundnuts have been widely used as components of fortified food. There are some reports of chickpeas, pigeon peas, mungbeans, and others being used in research and pilot feeding programs of Indian institutions. One quarter of one percent lysine added to wheat flour increases its usable protein by 1/3; chickpea, pigeon pea, mungbean, beans and other food legumes with lysine contents of about 5 to 7 percent of their protein should perform at least that well. For example, corn and cowpea in a 50-50 ratio has been reported to improve the PER from 1.22 for 100 percent corn to 1.84.

Efforts to develop manufactured food legume products or utilize them in fortification programs should be continued and intensified. But as a first priority, much greater importance must be assigned to legumes prepared by ordinary household methods. It is in this form that their use can most easily be extended, particularly in rural areas of the developing world where the need is greatest. Predominantly cereal eating peoples will remain so, and will continue to eat legumes as a supplement to their diets. They are not likely ever to become the principal component, but they can add significantly to the protein intake of people who are dependent on a predominantly cereal diet.

[Excerpted from "Pulse Production—Status and Potential," a paper presented to the "Workshop on Breeding and Fortification," held at Annapolis, Maryland, 7-9 December 1970, convened by the Office of Nutrition, U.S. AID.]

# Triticale, A Wheat-Rye Grain

Judy Fowler

[Experts appear divided about the prospects of a new crop—triticale, a wheat-like cereal that is man-made by selectively crossing wheat and rye. Its virtues are high protein content and an apparently high yield potential, but the latter has still to be established.]

Triticale seed was marketed and planted in the U.S. on a large scale for the first time last fall (1970) in an area estimated as high as 300,000 acres. The plant is being tested in a dozen states and Canada.

By 1975 it will be a "major" feed and food grain, predicts Earl Collister, president of International Grain, Inc., one of two companies that are developing and selling triticale. International Grain advertises that its variety, Graze Grain 70, "normally produces 50 percent more grain than wheat or rye" and that it contains nearly 19 percent crude protein, compared with 9 percent protein in corn and 10 percent to 11 percent in wheat. The company claims that six heifers can graze on an acre of irrigated triticale all winter and gain up to two pounds a day under ideal conditions and good husbandry; by contrast, barely two heifers can be grazed successfully on an acre of combined wheat, oats and rye, a common mix in Texas. The other company selling triticale seed, FasGro Seeds, Inc., a Prochemco, Inc. subsidiary, makes more conservative claims. Prochemco's president, Paul Engler says: "Right now it just won't outproduce hybrid corn on a dollar-per-acre basis. But the exciting thing is the varieties that will be coming out in two to five years." FasGro plans to bring out two new varieties in 1972.

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Many scientists agree that the best of triticale is yet to come. Wheat-rye crosses date back to 1875, but the resulting seed was sterile. This problem was solved in 1937, but the species remained unsatisfactory until 1956, when durum, the hardest wheat grown in the U.S., was substituted for regular wheat in the crosses. In 1964, B. Charles Jenkins developed a light-insensitive cross that would grow both in the long winters of Canada and the short winters of the southern U.S. He is a strong believer in the potential of triticale, as is Norman Borlaug [see pp. 6-14]. But some scientists are more skeptical; they argue that triticale isn't as productive as its proponents claim. Because the seed head of triticale is twice the size of a head of wheat, triticale seemingly should yield twice as much grain. But Louis Reitz, a wheat researcher in Beltsville, Maryland, says the heads on the triticale varieties that he has tested develop less than half of their possible seeds; the best tests showed triticale yields about equal to average yields of wheat, and most varieties he tested didn't yield even that much. He also says triticale has several other weaknesses, including that it isn't very winter-hardy.

**Triticale on left**
**Wheat on right**

But the triticale seed companies say the winter crop that will be harvested this spring has survived the winter very well. The other findings are unfair, they assert, because the new crop is being treated and handled too much like wheat: in some cases triticale may need to be planted earlier in the fall than wheat; triticale has a vigorous root system that has different water requirements than wheat. In addition, triticale needs almost twice as much fertilizer as wheat; "But the farmer can still make a $4 return for every fertilizer dollar invested," Mr. Collister claims.

Even the most skeptical scientists aren't completely discounting triticale, however. Mr. Reitz says that with new strains that fill out their seed heads better, triticale may find a market as a supplemental feed grain crop, possibly acting as a buffer against such calamaties as the southern corn leaf blight. It isn't as easily milled as wheat, but because triticale has more protein and lysine than wheat, food companies are exploring the possibilities of using it in breakfast foods and snacks.

[Excerpted from "Triticale, a Wheat-Rye Grain, Is Deemed Revolutionary by Some, a Flop by Others," The Wall Street Journal. New York, 1 March 1971, p. 18. ]

# Agricultural Research in Developing Nations

Albert H. Moseman

[Agricultural research has lagged seriously in developing countries. It is essential that they develop their own research capabilities; but this will only come about with understanding and commitment by governments and a purposeful planning of personnel and organization.]

A good many interrelated problems of continuous agricultural growth and development cannot be assessed and resolved from an international perspective. Most of them will require intimate knowledge of localized conditions, whether we consider the soils and climates of various cropping regions or the ethnic and social features of specific communities. Specialized international research institutes have been, and will probably continue to be, resource centers and distribution points for innovations which will then require adaptation to specific local environments to extract maximum benefits. These institutes will, therefore, play an important but a partial and transitional role in world agriculture. It is increasingly important that each developing nation build its own research capability, not only to supply new biological inputs but also to furnish the guidance for farmers and the understanding of the multiplicity of interacting factors associated with sustained economic development.

Many international technical assistance programs have been concerned with some aspect of agricultural institution building, but few have been directed toward the formation of national systems of agricultural re-

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search. We still have lamentably few effective research centers for agriculture in the developing nations today. It is evident that the research component will not be built into the agricultural resource structures of developing nations unless there is a concerted effort to bring this about. We should not expect research capabilities to emerge automatically from programs concentrated on building educational institutions. It is also doubtful whether any substantial measure of new science and technology can be generated as a residue from projects conducted by persons concerned primarily with extension.

In considering the applicability of the U. S. agricultural research system to developing nations, we should not assume that its specific organizational pattern or its evolutionary history will be directly relevant. The individual developing nations have different requirements to be met by their vocational schools and colleges of agriculture; these should be fostered and developed as needed. But the building of a national capability in agricultural research should not be submerged in an amorphous educational-research-extension complex merely because this form of organization has been useful as a part of the national system in recent decades in the United States.

## Agricultural Research Organizations in the Developing Nations

Looking at the newly-independent nations and Latin America, there has been little improvement in indigenous capabilities for agricultural research over the past 25 years. In the former colonies there is a rather consistent pattern (most clearly seen in the larger ex-British colonies) of central research institutes concentrating on fundamental or basic studies related to specific commodities—usually export crops such as rubber or cocoa. Only limited attention has been given to the broad-scale adaptive research essential for agricultural diversification and modernization. Research is not a major activity of the colleges or schools of agriculture in many developing countries. These are primarily teaching institutions with curricula and procedures strongly guided by the universities to which they are affiliated. In India and Pakistan there are Councils of Agricultural Research which provide financial support to selected projects, but in the absence of a strong national research infrastructure, the relatively modest and usually short-term allocations of funds to narrowly defined projects within special disciplines furnish limited practical or cumulative benefit. India, however, has taken positive steps in the past decade to develop All-India research projects and to strengthen its national organization for adaptive and applied research [see pp. 39-42].

In general, agricultural research in developing nations is more personalized than organized, and depends largely upon the initiative, vigor and level of training of individual research workers. The

sugarcanes from the research station at Coimbatore, India, and the "noble canes" from Java have been important resources for developing the sugarcane industry around the world; and individual British, Dutch, French and Belgian scientists have made outstanding contributions to the understanding of biology and agriculture in the tropics. But these contributions have diminished since World War II, in part because of the loss of expatriate scientists following independence, in part because of the efforts to borrow technology through "extension" programs, and also because of the strong emphasis in many developing nations on industrial development. The major limitation is the lack of support by political and administrative leaders for the research to produce innovations.

Research personnel. The lack of scientific manpower is the major limiting factor in the upgrading of agriculture in most developing nations today. The Minnesota Agricultural Experiment Station has more Ph. D. -trained personnel at two of its Branch Experiment Stations than does the entire Research Branch of the Division of Agriculture of the Government of Malaysia. The large number of research scientists in the United States, and the concentration of multidisciplinary teams at major research centers, together with the dispersal of well-trained personnel to local experiment stations, has an important impact on the extension of technology to farmers. The extension worker in northwestern Minnesota has a proved resource—from the nearby experimental farm—to offer to his farmers. This is in sharp contrast with the task of extension workers in Asia in recent years, who are confronted with the responsibility for recommending the improved rice or wheat production technology developed in the Philippines and Mexico which has been subjected to little adaptive research and only limited testing in local research stations.

The tasks of crop breeding and improvement, soil and water management, disease and pest control, livestock improvement and management, and animal health problems, etc., are as complex in tropical agricultural regions as they are anywhere in the U.S., and usually more so. The economic and social problems also are equally difficult and the same level of research competence is required to meet them. The training and experience in conceptualizing a problem and organizing an investigation to resolve or learn about it is acquired largely in the M.S. and Ph.D. training programs. Until the level of professional capability of agriculturists in the developing countries is raised, not only for research but also for extension and advisory services, much of the technological inputs will continue to be necessarily second-hand, and probably second-class.

Some of the developing countries have substantial numbers of individuals who have received advanced training in the sciences related to agriculture at universities abroad. Although the level of academic

training, through the M.S. or Ph.D. degree, provides a measure of intellectual competence, the in-service or working experience in experimental methodology is equally important. This competence to plan and carry out research varies widely in the developing nations, and the provision of such training in experimental projects in actual field and laboratory research has become an increasing problem. A prominent feature of the Rockefeller Foundation agricultural programs has been the strong emphasis on in-service or working experience in conducting research. Over 700 young Mexican colleagues have been trained in this apprentice relationship, and similar in-service training has been a part of the Foundation programs in Colombia, Chile and India. These national programs, and the international research institutes for rice in the Philippines and for corn and wheat in Mexico, are especially effective in providing this type of training. The personal characteristics of an effective agricultural scientist, his vigor, enthusiasm and dedication to the task of problem-solving may be enhanced or diminished by organizational support and working environments. Too often research personnel in developing countries are criticized for a lack of willingness to get their hands dirty or to work in experimental plots; it is not usually appreciated that the absence of a solid institutional base, with attendant career uncertainties, may be important contributory factors.

If developing nations are to move into modern science-based agriculture, they cannot depend only on external aid for advanced training and for giving their nationals the requisite experience. They must invest their own funds—and invest heavily—in building this national research capability. An effective pattern might include: 1) in-service training in experimental methods for field and laboratory research through apprenticeship in well-designed, problem-oriented research projects in the home country, in another country in the region, or at one of the specialized regional or international research institutes; 2) following the in-service experience, proceed with training to the M.S. degree level at an institution in the home country, within the region, or at a college of agriculture associated with one of the regional or international research institutes; 3) for those especially suited for research leadership, continue the training through the Ph.D. level at institutions—at home or abroad—selected on the basis of their suitability for the specialized needs and interests of the individual. At this stage the primary concern would be for education in depth in a specialized area, combined with reasonable breadth of exposure to related scientific disciplines.

Career specialization. The lack of a strong and stabilized organizational structure for research, along either commodity or problem lines, fosters too frequent transfers of research workers from one project to another. It is not uncommon for a plant scientist to have worked on three to five different crops over a ten-year period, with

the moves motivated primarily by modest salary advances in each new field. Such transient personnel contribute little in advancing technology during their careers. Another limiting factor is the tendency to place responsibility for a broad scope of research in the hands of a single individual. In some developing countries it is common practice to designate one economic botanist at a research institute as the leader for crop breeding and improvement research for a number of major economic crops such as wheat, cotton, sorghums, millets, oil seeds, etc. Even though he may have a sizable number of lesser trained subordinates, no one person, no matter how competent, can furnish incisive and progressive leadership to this scope of research.

Other program deficiencies. The concentration of attention on export crops has resulted in inadequate concern for improved production of food grains and feed crops, or to the design of diversified cropping systems to achieve maximum productivity of land and water resources. An especially neglected area is research on soils and water management, including the conservation and use of rainfall. Few countries have given serious attention to livestock improvement, and the research on economic and social problems in agriculture is extremely deficient. The emphasis of research institutes on fundamental studies has tended in many instances to limit attention to practical solutions for immediate problems or hazards which inhibit productivity. Agricultural research organizations are frequently organized on a discipline basis, i.e., divisions of botany, chemistry, mycology, entomology, etc., with a tight compartmentalization which inhibits joint attention to complex agricultural problems. Domination by non-technical administrative personnel in decisions on the development of budgets, the release of funds, the recruitment and selection of professional staff, the approval of travel, the purchase of equipment and supplies, and similar functions may be another serious handicap. The inadequacy of research facilities—laboratories, field stations, and scientific instruments—is also a general handicap. Perhaps the most common deficiency in agronomic research is the lack of precision in field experimentation because of plot lands poorly suited to exact and reproducible trials, with inadequate control of irrigation or moisture management and ineffective weed, disease or pest control.

The limitation in research capability in developing countries not only restricts the amount and quality of research by the domestic organizations but also restricts, sometimes seriously, opportunities to utilize external scientific discoveries and technical assistance. Foreign experts and support cannot be helpful unless there is at least a minimum standard of local professional competence and research facilities for effective joint adaptive research endeavors.

## Agricultural Research Costs and Returns

The question is frequently raised as to whether developing nations can afford the investment in national institutions for agricultural re-

search. One type of answer would be the following: the new wheat and rice production technology puts the food supply team a leg up in the food-population race which is all too vital in large areas of the world. This temporary lead time will undoubtedly be brief, but such time as is available before the next famine threat should be used to strengthen the technological base to meet it. The next time around the needs will have to be met in larger part by national research capabilities. The food-deficit countries, therefore, cannot afford not to make the required investments.

More positively, it is important to recognize that the international reservoir of potentially applicable science and technology for agriculture is much greater today than it was a century ago; the opportunities for well-chosen national adaptive research activities are significantly greater, and they are growing rapidly. Nations willing to make substantial investments in the larger international jet aircraft, or for development of national television systems, could probably afford the more modest funds needed to strengthen research capabilities for modernization and steady growth of their agricultural economies.

Numerous estimates have been made of the returns from investments in agricultural research, based on studies of specific advances. For example, a study by Arditto-Barletta showed that from 1943 to 1963 Mexico received an annual benefit of 290 percent for every dollar spent on the cooperative corn and wheat improvement research program. Estimates of the value of the new wheat and rice production technology in Asia suggest that the annual benefit from increased rice production alone reaches a level of $500 million.

There is a divergence of opinion about the need for national research capability in the smaller developing nations. The establishment of regional research centers, each serving several countries, is proposed as an alternative. Steps are being taken to develop regional centers in Southeast Asia through the auspices of SEAMES (the Southeast Asia Ministers of Education Organization) for example, and this approach has much to recommend it.

## Planning National Research Systems

The initial step in strengthening national research capability is the recognition of its importance by the political and administrative leadership. Leaders of a number of countries in Asia are taking positive steps to assess and strengthen their agricultural research capabilities. This type of activity has been underway in India since 1955. The Government of Pakistan, with the cooperation of the U. S. Agency for International Development (AID), arranged for a review of its agricultural research capabilities in 1968. The Government of Malaysia arranged for a similar review, and in 1969 the Malaysian Agricultural Research and Development Institute was created with responsibility

for all agricultural research (except rubber) throughout the country. The Government of Indonesia, following one of the recommendations of a joint meeting sponsored by the National Academies of Science of the U. S. and Indonesia, arranged for review of its agricultural research organization and programs by an Indonesian-American team in 1969. The Joint Commission on Rural Reconstruction (JCRR), in Taiwan, requested the International Rice Research Institute to conduct a review in depth of the crop research capability in Taiwan, with special emphasis on rice; this was done in May 1969.

The size of a national organization, the number of regional or field research centers, and the complexity of the research system will of course depend upon the scope and diversity of the agriculture of the given country. The basic components or elements of such a structure normally should include the following:

1. A strong national center for background research and for conceptual and coordinating leadership for national and regional projects. The Beltsville Research Center provides this resource in the U. S., and similar national headquarters are found at Chapingo, Mexico; Tibaitata, Colombia; La Molina, Peru; La Platina (Santiago), Chile; and the Indian Agricultural Research Institute near New Delhi.

2. Regional centers for adaptive research and specialized attention to the agricultural requirements of the major cropping regions of the country.

3. Localized research and/or verification and testing stations designed to fit innovations to specific soil and climatic conditions.

The concentration of competent scientists from various disciplines at the national headquarters will ensure most effective use of scarce talent and specialized equipment, in the same way that specialized research institutes make most efficient use of manpower and laboratory-field station resources. The level of competence at the regional stations should be similar or about equal to that of the central headquarters, but with smaller numbers and a mix of scientific disciplines determined by the nature of the problems of the region. The competence at the localized field stations should be of the B. S. degree level of training at the beginning, with upgrading to the M. S. and Ph. D. level in time (as has occurred in the branch experiment stations in many of the states of the U. S. ).

There is some difference of views about the concentration of scientists at a given location as contrasted with their dispersal to a number of sites in an agricultural area. The desirability of concentration is clearly evident if we accept modern science and technology as charac-

terized by multidisciplinary teamwork attention to the interrelated problems facing the farmer. This has been the experience in the U.S. and also in the Rockefeller Foundation programs overseas. In theory, it would be desirable to have the central headquarters located in the major agricultural area of the country. In practice, however, it has proved essential to have the major research center relatively close to the seat of the national government, to ensure effective communication between the leaders of the research programs and the political-administrative leadership of governments concerned with national planning, budgets, etc. Experience with the rapid application of the new wheat and rice production technology in Asia demonstrates the importance of support from top government leaders for these technologically-based, intensive agricultural production programs. The central research station should, therefore, serve in a true sense as the technical arm of the Ministry of Agriculture. The station should be near enough to the capital city to facilitate communication, yet sufficiently distant to avoid excessive interference by non-professional visitors.

Organizational structures should be designed to fit the needs of a given country. There are numerous ways to assemble scientific talent, and a national agricultural research organization should accommodate an interdisciplinary, problem-oriented approach. It should have sufficient operational flexibility to permit shifts in emphasis on major and emergency problems as they arise, but should normally aim at stability. One organizational pattern, proposed for the Malaysian Agricultural Research and Development Institute, offers an example which other countries may modify to meet specific national needs or priorities.

A. Crop Improvement Research Division
   a. Oil Palm Research Branch
   b. Rice Research Branch
   c. Feed and Fodder Crops Research Branch
   d. Vegetable Crops Research Branch
   e. Tree Fruit and Beverage Crop Research Branch
   f. Cocoa and Coconut Research Branch

B. Animal Improvement Research Division
   a. Animal Nutrition Research Branch
   b. Poultry Research Branch
   c. Meat Animal Research Branch
   d. Dairy Research Branch
   e. Inland Fisheries Research Branch

C. Soils, Water and Engineering Research Division
   a. Soil Classification Branch
   b. Soil Fertility and Management Research Branch

c. Water Management Research Branch
d. Agricultural Engineering Research Branch

D. Crop Protection Research Division
a. Insect Pest and Disease Control Research Branch
b. Pesticide Materials Research Branch
c. Rodent and Bird Control Research Branch
d. Weed Control Research Branch

E. Crop Utilization and Food Technology Research Division
a. Processing and Utilization Research Branch
b. Food Technology Research Branch
c. Crop Quality Analysis Services

F. Economics and Statistics Research Division
a. Production Economics and Farm Management Research Branch
b. Marketing Research Branch
c. Experimental Design and Statistical Services
d. Agricultural Policy Branch

Where a nation is divided into a number of states or provinces there are differences of opinion about the degree of centralization, and of participation by national governments in agricultural research. Those favoring major responsibilities for the states are concerned about: 1) impediments of bureaucracy or procedural restraints associated with large-scale organization, 2) difficulties posed by highly diverse agricultures, particularly when associated with wide geographic dispersal, and 3) the notion that agriculture and rural development should have a strong "grassroots" orientation for planning and implementation.

These disadvantages of centralization are offset by the benefit of the stronger national budget support and more effective use of specialized personnel and equipment through integrated national programs. National governments must be concerned about agricultural improvement as an integral part of a total national development. Distance or geographic separation should present no particular problem in the outreach of national research. To limit the central government role in research to a generalized function of planning and fund granting is not sound for most developing nations. The U.S. experience demonstrates the value of full participation in conceptualization and planning, as well as in implementation of research, by scientists from the various disciplines involved in a coordinated effort. In developing countries such joint participation has proved to be equally important in ensuring follow-through on all aspects of coordinated programs. The question of rural or grassroots involvement, on the other hand, requires special attention; the land grant colleges were established in each state in the U.S. to give primary attention to the local needs of rural people. The

limited number of agricultural research workers in most developing nations, however, precludes having such multidisciplinary team capability in local centers, for the present at least.

Linkages between research, education and extension. The sharp focus of this paper on research systems, and the thesis that directed research of real impact in fostering growth cannot be generated as a by-product from isolated institutions developed primarily for teaching purposes, does not minimize the significance of the teaching function. At least one agricultural university should be established in all nations with a significant rural population or agricultural sector to furnish effective education for agricultural scientists and extension specialists through the B.S. degree level. Most developing nations will eventually need several such institutions. Effective functional linkages between research and education should be considered not only from the standpoint of utilizing trained scientists for teaching, but also to ensure the exposure of all students to the experimental methods of science. This is especially important for advanced students at the M.S. and Ph.D. level.

For the dissemination of improved technology, extension specialists—subject matter specialists—should be located at the principal research centers. These specialists would be responsible for planning adaptation and verification trials, in collaboration with state or local extension workers or others responsible for transmission of new technology and related production inputs to the farm level. The broader role of "information services" must also be kept in mind, with attention to the communications facilitated by library and documentation centers, publications, etc. The deficiency in such information resources is one of the most significant features of most countries where agriculture is less advanced.

[Excerpted from Building Agricultural Research Systems in the Developing Nations. New York: The Agricultural Development Council, Inc., 1970, pp. 18-19, 30, 57-65, 98-109.]

# Recent Accomplishments of the Indian Agricultural Research Institute

M. S. Swaminathan

[A well rounded program of agricultural research in India has produced some valuable results in devising multiple crop patterns suitable to local conditions, in developing new varieties of pulses, cotton, fruits and vegetables, and in investigation of animal feeds. Ongoing research on dry-farming problems promises further results.]

## New Wheat Varieties

The scientific ingredients that have fostered progress in wheat production in India are: 1) the development of photo-insensitive and fast growing varieties have opened up the possibility of extending wheat cultivation to numerous new areas like the Tungabhadra region in Andhra Pradesh and Mysore and several parts of West Bengal, Orissa and Tamil Nadu. 2) Sowing wheat as late as January in the major wheat areas has been rendered possible through a combination of breeding and agronomic techniques, so that even if rains come late sowing of wheat is still possible. 3) In irrigated areas, unusual new rotations such as sugarcane-wheat, potato-wheat, cotton-wheat and winter vegetables-wheat have become both possible and popular.

I consider the agronomic practices developed at this Institute for sowing wheat late, and for harvesting four crops a year without detriment to the long-term productivity of the soil, as among the most significant of our recent research contributions. For example, an estimated 400,000 hectares of late wheat were sown in late December and January in 1968/69 as a result of a gov-

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ernment campaign. The four-crop relay technique involving rotations such as wheat-Baisakhi, Moong-hybrid, maize and potato has become popular in the Punjab. Where initiative has been shown in providing credit, as was done by the State Bank of Patiala, entire villages have taken to growing four crops in a year. Our new mixed cropping techniques enable the growing of two additional crops, wheat and moong, in the sugarcane fields of northern India.

Another important cause of instability in the production of wheat is the incidence of diseases, particularly rusts. Our mycologists initiated a systematic rust survey and surveillance program in 1968; fortnightly bulletins on the rust situation are sent throughout the country and to cooperators abroad. So far black rust is absent from the northern plains but has been widespread in Peninsular India, both in local varieties and in the high-yielding strain, Kalyan Sona, which is now the most widely cultivated dwarf wheat in India and Pakistan. While it is resistant to many races of all the rusts, the very spread of this variety has led to the selective buildup of the races to which it is susceptible, like race 122 of black rust. The search for new genes for resistance is on, and I am glad to report that a new gene conferring resistance to race 122 of black rust has recently been identified. We are also giving attention to the identifiaction of varieties with generalized resistance. Our latest reports show that brown rust is prevalent throughout the country and that yellow rust is heavy in isolated pockets in the foothills of Himachal Pradesh and Uttar Pradesh, though rust is unlikely to do any serious damage to the wheat crop this year.

Recent experience with wheat production should illustrate the importance of building up a strong research and training base before a field program is initiated. When changes are made in production technology leading to alterations in crop ecology, new plant-pest-pathogen-man relationships develop. For example, we lay stress in wheat breeding on selecting plants with leaves which are broad and which age slowly so that the harvest of solar energy can be maximal. Such leaves apparently are good food for insects, however, and last season we found an invasion of army worms and cut worms in the wheat plots for the first time in our long experience with this crop. But for the fact that we have some gifted entomologists on our staff, the crop would have been wiped out.

## Rice Production

The stagnation in India's rice yields is a good example of the impossibility of increasing production solely with the help of research carried out in other countries. When I first saw the grains of the exotic dwarf rice varieties upon which the hopes of the High-Yielding Varieties Program were based, I was convinced that unless we evolve varieties which combine the good qualities of our widely grown types

with the ability to respond to fertilizers, we cannot make a significant advance in rice production. In retrospect, this inference has proved to be correct and we are proud to have developed at this Institute within three years some outstanding Basmati varieties with a high-yield potential. We have also identified new sources of resistance to the bacterial blight disease in material collected from Assam. Many new varieties combining resistance to stem borer, fertilizer response and good quality are under testing. The irrigation-drainage cycle, the correct methods of applying fertilizers and the pest control schedules necessary for high yields have all been worked out, and I am confident that a major advance in rice production in north India will take place when seeds of the new strains are available for large scale cultivation.

## New Varieties of Other Crops

Among the varieties released or multiplied recently are H. B. 4 Bajra; Swarna, a variety of Jowar which is as high yielding as the hybrid CSH 1; Aruna, a castor variety which has a duration of only 110 days; the cotton strain Sujata, with a staple length of 1.25 inches and with a spinning value of 86 counts under mill conditions; several new plant types of rape and mustard; and fast growing varieties of the pulses Moong and Arhar. There is also good news for fruit and vegetable growers. Four new mango varieties have Dasheri, Neelum, Totapuri and Chousa in their parentage, selected out of nearly 40,000 crosses made during the last few years, are likely to add soon to the rich diversity of mangoes available in north India. These varieties will show regular bearing, unlike our present varieties in the north which bear well only in alternate years. New varieties of eggplant (brinjal), radish and turnip and a nematode-resistant variety of tomato have also been developed.

New avenues of nutrient supply have been explored. The soil fertility map of India has been revised incorporating the data from 1.3 million soil tests. The development of efficient strains of Rhizobia to increase nitrogen availability from biological sources, as well as the standardization of techniques for using basic slag (an unused by-product of the steel industry) in 6.5 million hectares of strongly acid soils, are research contributions of significant value in nutrient supply. These findings do not involve huge capital investments for exploitation but are based on either making nature work for us or on the conversion of wastes into plant food.

## Nutrition

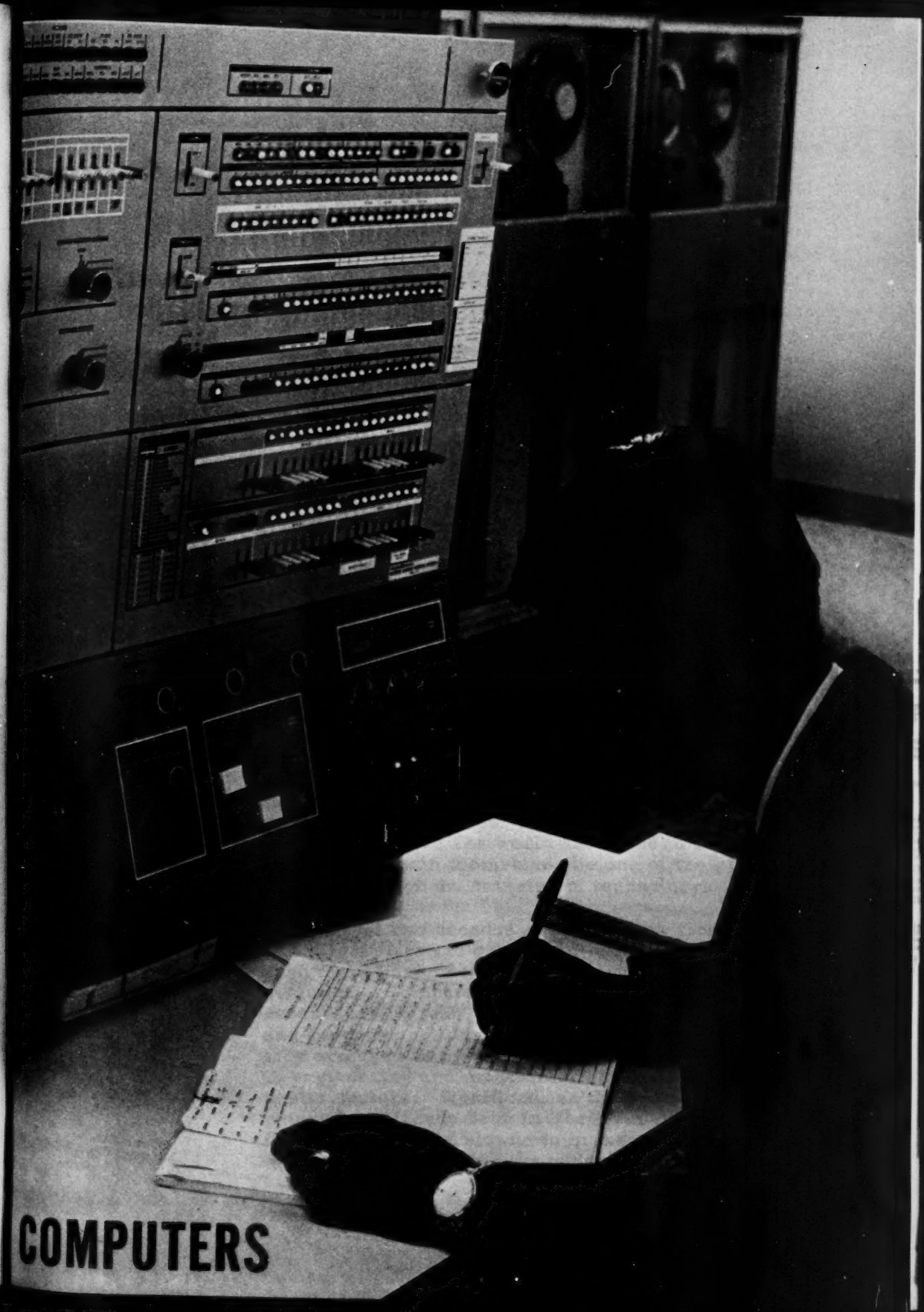
Our research on the genetic betterment of nutritional quality of cereals has made further progress. Maize hybrids with 12 percent protein, and 3.9 percent lysine in contrast to only 1.8 percent present in Ganga 3 and Ganga 101, are being tested. These new hybrids and

composites will help to build a prosperous poultry industry. Substantial progress has also been made in the development of high quality fodder grasses so as to render the use of concentrates unnecessary in the dairy industry. There is ample data to show that through better feeding the milk yield of even nondescript cows and buffaloes can be increased by 50 percent, and with suitable crop and land use patterns the 50 million underutilized milch animals in the country could be made to yield substantially higher quantities of milk. If genetic improvement were also undertaken on a wide scale, the scope for increasing milk products would be immense. The genetic upgrading of protein quality, increased production and consumption of pulses, and the exploitation of the vast neglected cattle wealth of the country will help to eliminate protein malnutrition, particularly in the young, and to make farming more remunerative.

## New Vistas in Dry Farming

I have so far spoken chiefly about the happy prospects opened up for irrigated farms. Equally exciting is recent research and its implications for the betterment of production in unirrigated and chronic moisture-deficit areas. The approaches broadly revolve around simple but efficient methods of using rain and subsoil water, the cultivation of crops and varieties which are physiologically more efficient under conditions of moisture deficiency, and the application of fertilizers at deeper layers of the soil and through leaves. The development of fast-growing varieties, and the exploitation of the buffering effect of genetic heterozygosity on adverse environments, have helped to evolve new cropping patterns for unirrigated areas; and if nutrient supply can be assured, the production potential of such areas can be vastly improved. For example, in an experiment with Kalyan Sona, the application of 10 kgs. of nitrogen through leaves helped to increase the yield of barani wheat from 6.8 quintals to 10.2 quintals per hectare. Techniques have been developed for spraying over 30 percent urea solution through the use of low volume sprayers. This technique has rendered aerial spraying of urea economically feasible, and a cost-benefit analysis of foliar application of fertilizer to unirrigated wheat is underway.

[Excerpted from "Recent Research at the Indian Agricultural Research Institute," Indian & Foreign Review. New Delhi, Vol. 6, No. 14, 1 May 1969, pp. 9-10.]


COMPUTERS

CONSOLE OF A BANGKOK COMPUTER INSTALLATION WITH MAGNETIC TAPE UNITS IN THE BACKGROUND, THAILAND
[PHOTO: INTERNATIONAL LABOUR OFFICE]

# The Application of Computer Technology for Development

United Nations Department of
Economic and Social Affairs

[ The numbers and the variety of uses of computers have been expanding remarkably in the industrial countries, with significant impact on technology. In developing countries their use is far less than it should be; to accelerate their deployment, training in the computer field should be expanded. ]

Technology has an essential role to play in reducing the disparities between the developing and the developed countries. Computers are especially important in this context, because so many computer applications have a direct bearing on facets of the development process. Although in many respects the transfer of computer technology is like the transfer of any other technology, computers have a special position: in the course of introducing them to carry out a task, people are brought to reassess the whole way in which the task should be done. In fact, computers often lead to a re-evaluation of why the task is being done. This examination of ends and means is fully as important as the introduction of the computer itself. The world has come to recognize that computers can in themselves be one of the principal instruments for the transfer of technology.

It is just two decades since the very first electronic computers began to operate in 1950, and yet in this short span there have been three full generations of machine evolution. Computers were first used for science and research, and then were rapidly adapted to business and government administration beginning in 1953. Today they are used in the physical, social and life sciences, in engineering and manufacturing, and in the private and public sectors. Significant as the penetration of computers has already been in North America and Europe, there is no sign of slowdown in the rates of installation of new equipment or in the widening of the range of ap-

plications. But in developing countries, as with all too many aspects of technology, computer use is still slight. Even where computers have been introduced there is often underutilization of the equipment because, for example, there are not enough people with training and experience to apply the new methods. Concerted action for the transfer of computer technology to developing countries is of top priority.

A questionnaire was circulated by the UN Secretary-General to governments of member states to find out the number of computers and their uses in developing countries. Altogether 51 countries replied: of these governments, three indicated that they had no computers, five had one computer in their country and eight had more than one computer; many countries did not provide aggregate numbers. Occasionally the distribution of computers between the public and the private sector was given: Table 1 lists these figures. By way of comparison, in 1969 Canada had 259 computers in the public sector and 1,669 in the private sector; Japan had 154 and 5,447, respectively. The United States is a special case; there the number of computers was more than 50,000, with a total estimated value exceeding $20 billion, out of an overall value of $31 billion estimated for all computers in the world in 1969. In individual countries of Western Europe, the numbers of computers per billion dollars of gross national product in 1966 were 15-20 (25.5 in Switzerland), and the numbers per million of working population were 50-100 (138.7 in Switzerland); in the U.S. these numbers were 38.3 and 361.2 respectively.

TABLE 1. SOME EXAMPLES OF DISTRIBUTION OF COMPUTERS IN THE PUBLIC AND PRIVATE SECTORS IN DEVELOPING COUNTRIES, 1969

| *Country* | *Public sector* | *Private sector* | *Total* |
|---|---|---|---|
| India | 69 | 42 | 111 |
| Chile | 18 | 15 | 33 |
| Nigeria | 7 | 3 | 10 |
| Trinidad and Tobago | 7 | 7 | 14 |
| Iraq | 1 | 5 | 6 |
| Thailand | 6 | 7 | 13 |
| Republic of Korea | 10 | 4 | 14 |

SOURCE: Information based on replies of Governments of Member States to the Secretary-General's questionnaire.

## Brief Description of Computers

A computer is a device to process information; it performs arithmetical or logical operations on the data which are put into it. The physical parts of a computing system are called computer hardware. The major components are:

a) Input equipment: card readers, punched tape readers, keyboards, document readers;

b) Central processor: the unit which carries out the logical and arithmetical operations;
c) Memory: devices for storing both data and instructions on how to process the data; magnetic cores, magnetic disks or magnetic tapes are examples;
d) Output equipment: line printers, plotters or display devices.

Card readers are most widely used for input, but document readers are coming into use as their reliability increases, and some companies are developing equipment which enables data to go directly from a keyboard to magnetic tape. Most high speed memories are made with magnetic cores; intermediate speed memories use magnetic disks or drums, and magnetic tapes serve as slower speed memories. Access time, the time it takes to transfer an item or group of items from its location in storage to where it is needed, ranges from microseconds (millionths of a second) for cores to hundredths of seconds for disk and drums, up to minutes for random access to information on magnetic tape. The price for storing an alphabetic character varies with speed, from $0.25 for core storage to perhaps $0.0001 for storage on magnetic tape. A typical line printer prints a line 132 characters long and at rates of 1,100 lines per minute. Manufacturers are beginning to offer display devices that show pages of text and can do curve plotting.

Software. Before a computer may be used a program must be established in its memory. The program is a set of instructions specifying a sequence of arithmetical and logical operations to be applied to a given set of data, a plan to be followed. When the instructions refer directly to the hardware components of the computer they are converted simply into electrical signals which activate the physical devices. Such a list of instructions and associated data is referred to as a machine language program. Machine language programming is tedious and may give rise to error. Therefore, a symbolic assembly language has been developed and a corresponding translating program written: this last is a computer program which when executed causes the computer to accept statements in the assembly language and then generate machine language commands. This permits the user to refer to quantities by symbolic names. Along with assembly languages came the technique of developing programs in sections (called subroutines) in such a way that they can be used with other programs, and libraries of subroutines can be collected and distributed.

Symbolic assembly languages were followed by problem-oriented or procedure-oriented languages. The first of these was Fortran (formula translator) which accepted statements of a mathematical type. This was followed by Algol (algorithmic language) and by Cobol (common business oriented language). In another class are special purpose languages: SIMSCRIPT, SIMULA and GPSS designed for specifying machine tool control; IPL-V, LISP, and SNOBOL are string processing languages for symbol manipulation.

The operating system was a highly significant software development. This is a resident program which allows the computer to accept and process one job after another without requiring operator action between jobs. There is no waste of time between jobs, an especially important factor when there are many small jobs each requiring only a few seconds to run. Even in large installations working on large problems, numerous short runs are required to "debug" subroutines, that is, to check them for errors. When the pieces are correct, the whole program is assembled and tested on small sets of data. A good operating system can double the throughput (number of jobs run per hour) of a computer system.

Systems have been developed that accept a job stream, line up the jobs and select them to be run according to priority. Short "debugging" runs to find errors can then be put ahead of long production problems. High performance systems have several input devices and printers, permitting several job streams at a time. Multiple input/output channels can be established at terminals in remote locations to make a remote job entry system. Since computer hardware is costly, the first operating systems were designed to keep the hardware busy even at the price of making users wait. A more recent mode of computer operation is time-sharing, an arrangement where one computer serves many users in turn, each at his own terminal, in such a way as to keep users occupied between turns.

## Uses of Computers

File maintenance. Most applications of computers in government and business center around file maintenance. A file to be processed by computers is a collection of records stored in machine-readable form, for example, on punched cards, magnetic tapes or magnetic disks. File maintenance consists of several basic processes including editing, adding and deleting records, updating the file by entering transactions, sorting and selecting of records, and preparing reports. The central operation is a computer run where transactions are entered against a master file to produce an updated master file and various reports listing the activity which has taken place. Inventory maintenance, retail accounting, credit billing and payroll processing are a few of the business applications which fall into this pattern. In government, any kind of record-keeping process can be carried out as a file maintenance operation. In developed countries these processes have been converted into computer form for several reasons: to keep costs down by reducing the number of personnel involved, to manage large volumes of transactions, and to have files in such a form that they can be used in more sophisticated operations related to planning and management where the benefits of computers can be especially great. In developing countries the first installations are often made by foreign companies undertaking the same kind of operations as their parent company in their home country.

Information systems. A machine-readable file is a natural precursor to an information system, a form of resource inventory which is coming to have central importance for all planning operations. An information system has the following properties: a) it is a large collection of records in a machine-readable form; b) unlike a file, the system is not constructed for a single identifiable purpose, nor is it subjected to periodical processing. It will be used, rather, for a number of possibly quite different purposes; c) it is available to a large number of users who may be quite remote, and who may even use terminals connected to it by communication links; d) accompanying the system is a set of computer programs for querying the data base, retrieving information, printing reports and so on. These programs are written in terms which will be familiar and convenient to prospective users.

An information system might be based on a manpower registry, a collection of medical records, an inventory of properties and buildings in a city, or all the laws and legal decisions in a given jurisdiction. The system with its computer and set of programs may be compared to a service utility. Since it will be expected to have a relatively long life, and since changes can only be made after their consequences have been examined and tested thoroughly, design features such as the record format and mode of use must be thought out very carefully from the beginning. It has many users, some of whom come to it regularly and others only occasionally. The investment, in the form of records, operating programs and training, will be very large.

The Data Bank and Information System of the U.S. Bureau of Labor Statistics is an example of an information system which has had a long history of use. It provides data for users on such items as employment status and duration, occupation, industry, sex, age, color, marital status, education and household relationship. In addition, summary employment statistics for local, state and federal regions, including information on hours of work, pay and labor turnover are entered. Monthly records are supplemented by others gathered on an annual basis and by various other agencies, for example, cross-section statistics on employment of scientists, engineers and technicians by occupation and by industry, and information on wholesale and retail prices. There is provision for entering any type of relevant time series into the system. With the system there is a problem-oriented computer language which is easily learned by the social scientist or statistician who wishes to use it.

Every government requires systematic maintenance of records if it is to function effectively, for example: a) population and demographic records; b) taxation records; c) production statistics by sectors, for example, agriculture, manufacturing, mining, construction; d) economic indices, foreign reserves and trade balances, national income, private and public debt, consumer spending, average prices, and

earnings, etc.; e) educational statistics, including number and types of schools, teacher training, educational level attained within the population, etc. Any system of maintaining records for a government depends critically on reliable data collection. Today it is not possible to envisage acceptable methods of data collection which do not contain at least some means of recording the data in machine-readable form and of applying certain tests for reliability and internal consistency. Very soon, however, a country finds that it needs computers to process and analyze the files, and to produce results for use by national and international organizations. Thus countries even in the first stage of development need computers for public administration. For large or more highly developed countries, the point at which several and then many computers are needed is soon reached. This is not to say that computers can be introduced into the public sector without clear understanding of the procedures to be automated, previous experience in carrying out the operations by manual methods, and intensive training and education. But given these factors, experience shows that the need to introduce computers may be justified.

Computers in planning. The most challenging way in which a computer can contribute to economic development is as a planning and forecasting tool in operations and economic research. In one basic planning technique, computers simulate the complex situations encountered in the operation of a plant or the movement of traffic through a city, thus making it possible to identify the cause of bottlenecks or predict the effectiveness of speeding up certain phases of the operation. Special computer languages, such as GPSS, SIMULA and SIMSCRIPT, have been written for these problems. A report prepared for the United Nations Conference on Trade and Development (UNCTAD) on port operations of Casablanca and Vancouver describes a typical computer simulation. The main program simulates movement of traffic in and out of the port, and there are satellite programs for the accumulation of data, the projection of future traffic requirements, the generation of traffic patterns and the printing of results. The program specifies features of the port, such as the tug and cargo sections, the queuing areas for ships, storage areas for cargo and hinterland transport, and storage means, and it adapts these to different situations.

In a model, mathematical equations are used to represent the dynamics of different parts of the system. The petroleum industry provides an outstandingly successful example, where for a long time the techniques of mathematical programming have been applied to schedule production for single refineries and refinery complexes; the economic pay-off of mathematical programming is well documented. In economic research, the technique of representing the economy of a country by an input/output matrix has also had wide acceptance. In other economic models, time series are developed for important indices such as international capital flows, exchange rates, government revenue and expenditure. The analysis of investment alternatives in

the Colombian transport system, sponsored by the International Bank for Reconstruction and Development (IBRD) is an example of a model for a developing country. In spite of the undisputed success of some of the techniques described here, it is necessary to exercise caution about them. Simulations are revealing only if they are coupled with an understanding of the basic processes involved. The same is true for models. Projections based on a model become increasingly subject to error as the prediction time is extended. All the methods depend on good data with which to calibrate the model and estimate the parameters, and these may be hard to obtain. A great deal of experience is needed to know how much confidence can be placed in the results, yet they hold considerable promise.

Engineering. One highly integrated computer system, applicable to a whole industry, is the Integrated Civil Engineering System, ICES. This consists of a large group of subsystems, each capable of helping an engineer to carry out a specific task which occurs as part of the design and construction of a building, bridge or highway. Subsystems are available for structural analysis and design, transportation network analysis, coordinate geometry calculations, bridge and road design, foundation problems, project management and control and the like. The feature which makes of this group a comprehensive system is the mutual compatibility of the representations and methods of dealing with data within the various subsystems, which allows information to be passed automatically from one to another. Other sectors of engineering where computers are common, both in education and in operational practice, are chemical engineering, where plant simulation is especially useful; electrical engineering, where computers are regularly used for design of motors, electronic circuits, antennae, etc.; and industrial engineering. Two computer techniques coming to the fore are process control, i.e., small machines which can monitor and regulate the flow of products on an assembly line or otherwise guide some aspect of a manufacturing process, and computer-aided design.

Libraries. Computer information systems are becoming essential to professionals in a wide variety of scientific fields where the "literature explosion" is experienced. Their importance is attested by the existence of VINITI, the All-Union Institute of Scientific and Technical Information in the Union of Soviet Socialist Republics, the worldwide documentation centers operated through the United Nations Educational, Scientific and Cultural Organization (UNESCO), and UNISIST, the project for a world Science Information System currently being sponsored by the International Council of Scientific Unions and UNESCO. New means of retrieving information, based on computers, are being tried in many places in the form of pilot project services offered by government institutions, scientific organizations, and private companies.

The Medical Literature Analysis and Retrieval System (MEDLARS) is an early example of an index publication and literature search service based on computers. MEDLARS tapes containing bibliographical listings for research articles in over 2,300 journals on medicine, public health and the like are prepared monthly. Search centers have been set up throughout the world for processing the tapes, and at those centers a doctor or scientist may submit a request to search for references on a given topic. Attached to each article are key words or descriptors which indicate the content. Appropriate descriptors are attached to any question posed to the system, and a search is made for articles which have descriptors matching those of the query. In the initial version of MEDLARS the time elapsing between query and reply is relatively long; a new version of the system designed to reduce the delay is being implemented.

Many libraries have set up bibliographical files in machine-readable form for their users. The sample excerpt below shows part of the print-out of a request for information on the effects of computers and automation on manpower employment put to the International Labor Office Library.

INTERNATIONAL LABOUR OFFICE, CENTRAL LIBRARY & DOCUMENTATION BRANCH

I.S.I.S. SEARCH NUMBER 1379 08/10/69

RETRAINING SCHEMES AND PRACTICES

29815 1968
WRIGHT HB
SOLVING THE PROBLEMS OF RETIREMENT.
LONDON, INSTITUTE OF DIRECTORS, 1968. 108 P.
COMPILATION OF ARTICLES ON PROBLEMS AND /PSYCHOLOGICAL ASPECT/S OF /RETIREMENT/ - COVERS /PUBLIC OPINION/ OF RETIRED /OLDER PEOPLE/, PROBLEMS OF INCREASED /LEISURE/, POSSIBILITIES OF /VOLUNTEER/ WORK, /TRADE UNION/ VIEWS, /EMPLOYMENT POLICY/S FOR /OLDER WORKER/S, /HEALTH/, /MENTAL HEALTH/, PRE-RETIREMENT /TRAINING PROGRAMME/S, /RETRAINING/ OLDER WORKERS TO IMPROVE /EMPLOYMENT OPPORTUNITY/S, /PENSION PLAN/S, /PART TIME/ WORK, ETC., AND INCLUDES A /DIRECTORY/ OF AGENCIES CONCERNED WITH RETIREMENT PROBLEMS IN THE /UK/.
ENGL

29605 1969
DANSK ARBEJDSGIVERFORENING
KVINDER PA KURSUS.
ARBEJDSGIVEREN (COPENHAGEN), 70(3), FEB 1969, 20-21. ILLUS.
MICROFILM
BRIEF NOTE ON THE NEED TO ORGANISE /RETRAINING/ COURSES FOR /MARRIED WOMEN/ INTERESTED IN TAKING UP /PART TIME/ EMPLOYMENT - COVERS /TRAINING PROGRAMME/S AVAILABLE TO THE PROSPECTIVE /WOMAN WORKER/.
DANI

29595 1969
BOEKEMEIER R
LANDWIRTSCHAFTLICHE BERUFSAUSBILDUNG NOCH ZEITGEMAESS.
AUSBILDUNG UND BERATUNG (MUENCHEN), 22(4), 1969, 69. TABLE.
MICROFILM
ARTICLE SUGGESTING REORGANISATION OF /VOCATIONAL TRAINING/ OF /RURAL WORKER/S IN /GERMANY (FR)/ TO CORRESPOND TO CHANGING /JOB REQUIREMENT/S IN RESPECT OF SUCH WORKERS - COVERS THE NEED FOR /TRAINING PROGRAMME/S TO PROVIDE /FURTHER TRAINING/ AND /RETRAINING/, THE /CURRICULUM/ OF RELEVANT /TRAINING CENTRE/S, ETC.
GERM

Education. The role of computers in educational data processing, as in the administrative processing of records, is well established.

Computers are needed in schools to teach computing and data processing courses, and formal degree courses in computer science and information processing are being established in many universities. Computers can also be used in the teaching process, and here there have been interesting developments. A method of teaching based on so-called programmed texts and teaching machines has been worked out: a body of material is presented in a sequential manner to the student, who is tested at various points and directed along different review paths according to his response. These simple teaching machines were followed by systems of computer-aided instructions, where students work at a terminal station, and a computer simultaneously directs a number of students through the course material. With the use of computer-aided instruction some remarkable rates of learning have been demonstrated, but in view of the current state of the art it is very dubious whether developing countries should embark on computer-aided instruction. However, computers are valuable for subjects in which it is extremely useful to be able to assign problems which the student solves with the aid of computers. Examples are numerical analysis, statistics and calculus. In business schools there has been long experience with management games, which are simplified mathematical models of competitive business or manufacturing situations in which the students make decisions on production, marketing, research funding, plant expansion and the like, transmitting their decisions via the computer and receiving from it information on the success of their play. Similar games have been used for political and military learning situations.

The examples above by no means exhaust the list of areas where computers are bringing about important changes. In medicine, for example, computers are having a highly significant effect on research and science, and equally important effects on hospital administration and patient care; some day in the future, no doubt, they will even affect methods of diagnosis. In industries such as warehousing, typesetting, and machine-tooling, computers have already brought about radical changes in practices or, at least, a clear indication has been given that they will do so. It cannot with confidence be predicted of any technology that it will remain unaffected by the existence of computers in the next decade.

In developing countries, the uses of computers which could contribute most to development are: in government planning and administration, in the collection and computation of statistics on production, trade and finance, in research and education, in public health and demographic analysis, and in the management of public industries. The most common existing applications, as shown in replies to the Secretary-General's questionnaire, are for demographic and census data, for government accounts and administrative records, in making statistical computations and in transportation uses. These applications are similar to those first made when computers were introduced in the public sector

of industrial countries. Questionnaire replies reveal that the clearest need in developing countries is for training and education in the field of computers, so that applications important to development can be undertaken. Because of the dependence on education, always a slow process, the expansion in use of computers cannot come quickly. But computers and the information systems that come with them will enable developing countries to plan on a national scale, and in ways that the industrially advanced countries are only now beginning to learn.

## Computer Costs

Computer systems range through large and intermediate to small systems (see Table 2). Recently a number of companies have been offering "mini-computers." These are satisfactory for certain areas of scientific or engineering computation, but since they have no significant capability for data handling and printing, they cannot be used for the data processing and administrative applications to development.

TABLE 2. EQUIPMENT AND CAPABILITY OF COMPUTER SYSTEMS OF VARIOUS SIZES

| | *System* | | |
|---|---|---|---|
| | *Small* | *Intermediate* | *Large* |
| Input ..... | Card reader 80-200 CPM[a] | Card reader 1,000 CPM[a] | Several card readers 1,000 CPM[a] each |
| High speed memory ... | 8,000-32,000 characters | 64,000-256,000 characters | More than 256,000 characters |
| Disk memory . | 0-1,000,000 characters (bytes) | 1,000,000-30,000,000 characters | More than 30,000,000 characters |
| Magnetic tapes | 0 or 1 unit | 2 to 4 units | More than 4 units |
| Printers ..... | 200-600 LPM[b] | 600-1,000 LPM[b] | 2 or more at 1,000 LPM[b] |
| Communication capability .. | Possible | Yes | Yes |

[a] CPM = cards per minute.
[b] LPM = lines per minute.

Currently, a small data processing system costs about $100,000; the cost of the intermediate system ranges from $500,000 to $1 million; large-scale systems cost more than a million dollars and will only be of interest at advanced stages. Because of the high capital investment, computers should be operated during evenings, nights and weekends when necessary; up to four shifts are possible if weekends are included. One of the striking differences between installations in developing countries and those in industrially advanced countries is that the former are often underutilized while the latter are often operating near capacity.

In too many cases computer centers have been set up without adequate operating budgets. No provision has been made for programming

advisers or for keypunch operators or other persons to help in the preparation of the data, always an important part of the work of a government computing facility; training costs may be neglected. Even "free" software has implicit costs. The center has to assign staff time to communicate with the supplier, see that the program runs properly on the local hardware, teach users about the programs and be able to adapt them to the local configuration. A computer center must be prepared to put much of its resources into software and into service aids for its users. A computer center even of modest size needs several systems programmers to keep the system up to date by installing new systems, languages, updates, releases and so on.

The main costs associated with a computer center are the following: investment costs such as feasibility study; construction or modification of a building, including installation of air conditioning, power service etc.; purchase of computer, furniture etc.; purchase of computer software; shipping and installation costs; initial complement of maintenance parts; data conversion; and initial training. Operating costs include personnel costs for management, typing and clerical help, systems and application programmers, operating and consulting staff, keypunch staff, maintenance staff, as well as education and training of staff; and supplies and recurring expenses such as electric power, paper, cards, magnetic tape and disks, and spare parts, rental costs for leased equipment, and costs for library materials (journals, texts, computer programs etc.).

In commercial installations the budget for personnel and supplies can be twice the hardware costs. In educational installations the budget is less than this, because the applications programmers are faculty members and students, not staff of the computing center. In developing countries the ratio of hardware to staff costs will be higher than it is in industrially advanced countries, but a significant budget will be needed for program advisers. The hardware vendor may contract to provide maintenance, although some installations in developing nations choose to do their own maintenance. In any case it will be necessary to maintain a supply of spare parts, and to know the vendor's techniques for fault detection.

Computer manufacturers offer their equipment both for purchase and for rent, and computers are rented perhaps more often than any other type of capital equipment. For most types of equipment, the amount paid out in rental will equal the purchase and maintenance costs in about four and a half to five years. Thus if it is expected that the equipment will be used longer than five years, it would be preferable to purchase it. In favor of renting as opposed to purchasing the machines is the fact that computer technology has been changing so rapidly; even if they do not become obsolete, in many situations the growth in their use is very rapid (a doubling every two and a half to

three years is common) and a country may find that it is outgrowing its computer installation and is faced with an expensive upgrading with a purchased machine. The counter-arguments to rapid replacement are that third generation hardware, together with the associated software, is likely to last longer than earlier models; and that it takes two or three years even to begin efficient operation, so that replacement times of less than five years are not economical.

It is often suggested that developing countries install older and less costly second generation computers, but there are arguments against this. First, the equipment is already obsolete when it is removed from service in the developed country, and the centers using it will not have the latest capabilities. Secondly, the serviceability of older computers is much less than that of new hardware. Thirdly, consulting help may not be available, because people are no longer familiar with the old software. Finally, since in the long run most of the money spent on a computing center will be for salaries and software, and since the value of the software for older equipment is much less, due to its reduced life expectancy, the real savings will be much lower than the apparent savings. The UN Working Group on computers noted in its April 1970 meeting that the arguments against older equipment are generally convincing; there may, however, be particular circumstances where an exception is in order.

Altogether, the complexities of computers are such that it would seem highly desirable to have a place where developing countries could obtain advice on these matters. This is especially necessary since the cost/benefits of computers will be different in developing countries from those of industrial countries. Developing countries certainly need a good selection of the archival material about computers. Methods of financing such acquisitions should be explored, for example through UNESCO and the professional societies. The current awareness material is also valuable, but here the acquisition problems are even greater, for they are usually offered on subscription for rates which can be prohibitively high.

The impact of computers on employment was raised in the UN Working Group, but it appeared that the information on this subject was too limited to justify conclusions at this time. It is hoped that more comprehensive analysis, with case studies, will be undertaken.

[Excerpted from The Application of Computer Technology for Development. New York: United Nations, 1971, pp. 3-5, 13-15, 28-33, 77-78, and 82-95. UN Sales No. E.71.II.A.1.]

# Computers in Less Developed Economies

Marvin M. Wofsey and Paul M. Dickie

[Developing countries should probably not computerize operations where semimanual methods are possible unless overall costs are actually less, and problems of personnel availability and training, power supply, spare parts and backup machines can be securely overcome.]

At the beginning of the 1970s the governments of less developed countries are facing decisions with respect to computerizing the routine functions associated with the rising level of government services. In contrast to their oft-stated policies regarding employment and training, and often unobtrusively, they have more and more frequently made the decision to use computers.

To illustrate: a government department in Latin America is charged with running one of the public utilities serving 40,000 customers, about 36,000 of whom are charged at a flat rate. The remaining 4,000 accounts are the large users who are charged on the basis of a rate schedule. These large users account for about 70 percent of the $1 million in annual revenues. In the past the utility was managed by an engineer who paid little attention to the business aspects of the operations. Principally as a result of poor billing and collection procedures, arrears have increased to almost $500,000 and government subsidies have had to be increased correspondingly. The government appointed a new manager; one of his principal tasks is to improve the accounting and billing procedures. At present the accounting and

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billing procedures. At present the accounting and billing procedures are dealt with manually by about 20 people with total costs running at $4,000 a month; most of their time is spent on accounting and billing for the large customers. There is currently a procedure which partially automates the billing of the 36,000 customers who are charged on the flat rate basis; it involves a machine to reproduce the bills and a manual addressing machine for duplicating the mailing addresses.

The new manager has three main alternatives: 1) improve the present manual system; 2) introduce a semimanual system incorporating the billing functions; and 3) computerize the operation. In the actual case outlined above, although the costs were substantially higher, the new manager's decision was to computerize. The reason for this decision was "greater efficiency," by which the manager meant fewer management and personnel problems as well as substantially fewer errors.

In an overall consideration of the country's welfare this decision was probably wrong. The country has high unemployment with a poorly trained labor force. In this situation manual or labor-intensive methods generally will yield the highest welfare for the country as a whole since they will result in increased employment and income (and it is hoped will increase the trained labor force). In addition, labor-intensive methods will reduce the drain on scarce capital resources, especially foreign exchange resources. In a free market economy this situation will be reflected in the relative costs. It will cost less for business as well as governments to use manual methods rather than invest capital in computer equipment. In the case described, the better solution is to use either a manual or a semimanual system from the point of view of overall welfare as well as cost.

This decision to use a computer was made not on a basis of relative costs but on the criteria of fewer personnel problems and fewer errors. The decision in favor of computers is more often than not made in conjunction with foreign experts from developed countries. Many of these experts have worked only with computer systems and are not familiar with manual or semimanual systems. Further, they can offer a software package requiring little adaptation that they are confident will solve the problem as well as provide efficiency over the long run. This is especially true for software packages for the second generation computers. Efficiency here may mean little more than conforming to the work habits of foreign experts. Of course, there are many computers in developing countries being used to excellent purpose. Nevertheless, the efficiency concept clearly calls for examination.

## System Effectiveness

Quite often the use of computers is advocated on the ground that they will cure the current problems of a system beset with human errors. It is recognized that human beings are more fallible than computers. Nevertheless, the computer cannot be expected to locate all errors in input data and to correct them. If the current system is riddled with human errors, isn't it logical to expect at least the same proportion of errors in computer input data? Possibly the error rate will be higher. Human beings can contextualize; computers cannot. A person would recognize a transposition such as—"He sat on the chari" to be "He sat on the chair." Computers would not be able to recognize and correct such errors. There is a fairly well-known computer phrase to illustrate this problem—GIGO—Garbage In, Garbage Out. The output of a computer will be no better than the quality of the input.

The computer has proved to be no panacea in the highly developed countries. Computer use brings special problems, many of them technical in nature. One must find systems analysts, programmers, computer operators, and people to maintain the computer. How is the personnel selection to be made? If it is decided to train local talent, how does one select those who have the potential to fill a technical position associated with computers? How and where should they be trained? What should be done to get clerks who are making many errors in the old system to submit error-free work in the new system? If a general program to complete a routine application such as payroll or inventory control is made available, who will adapt the system to the specific application? Furthermore, since changes are almost inevitable, who will maintain these general programs, and take account of the changes? On top of personnel problems, there are serious questions concerning quality and stability of electrical power and the need for maintenance and backup provisions for the computer. Before ordering a computer to correct deficiencies in the system, one should be sure that one is not creating more significant problems.

## Data Processing Personnel

Quite often the failure of a computer installation is attributed to problems associated with people—both managerial and technical. The requirements for a data processing manager are demanding. He needs both managerial skills and technical experience. Furthermore, he must be able to take a companywide or countrywide view of what he is trying to accomplish, while recognizing and forestalling many minor snags, any one of which can result in failure of the system. The recruitment and training of technical personnel is another major problem. If they are not available in a country, transportation costs and other fringe benefits, as well as comparatively high salaries, will be needed to attract them from abroad. The fact that foreign personnel tend to

leave after a relatively short time is still another difficulty. And there is the problem of language. Most of the valuable literature in the computer field is in English, although a considerable amount is in French, Russian, German, and Spanish. It is possible to write established computer programs without knowledge of any of these languages, but to become a good programmer it is necessary to read and understand computer literature in order to understand new and improved techniques.

## Electricity

The power requirements of computers are quite stringent. Voltage variations will cause malfunctions if they exceed allowable limits. If there is any possibility of the voltage exceeding these limits, voltage regulators will be needed. These regulators will take care of short surges or drops in power; power surges or drops could result in serious computer malfunctions and/or damage. Since computers run on electricity it is clear that anything that stops the supply of power will also halt completely computer production. If the supply is as variable or spasmodic as it is in many less developed countries, power problems could be significant.

## Computer Maintenance and Backup

Computers need regular preventive maintenance and intermittent emergency service if they are to operate for an acceptable part of each day. If the computer is the only one of its kind in the country, a complete stock of parts must be kept in the country. Furthermore, a well-qualified maintenance man must be there. If a single man attempts to service the computers in more than one country, protracted delays in repairing the computer can be expected. Even assuming that no two computers malfunction simultaneously, there will be considerable time lost if a computer in one country fails while he is in the other. Furthermore, if a complete stock of spare parts is not available, days can be lost waiting for a needed part to be flown into the country.

If the computer is out of service for a long period of time it may not be possible to revert to the former manual system, since all records may be on computer tape or disk. It may not be possible to get to these records if the computer is out of service. Also, the knowledge of how a manual system operates tends to disappear after the work is transferred to a computer. If the computer fails nothing gets done.

In order to forestall problems inherent in computer failure, backup provisions are needed even if degraded performance results; there must be another computer where the work from the computer that failed can be completed. Furthermore, this backup computer must

have the capabilities required by programs and also must be able to run such programs with little or no change. It is rash to assume that a program that runs on one computer will run on another computer, even though it may come from the same manufacturer, have the same model number, the same size memory, and identical peripheral units. Variations of the module of the operating system in use or different characteristics of particular units can cause a program which runs perfectly on one machine to fail ludicrously on another. It is necessary to run the same program on both systems before assuming that there is backup.

## Justification for Computers

A computer is an expensive piece of equipment. Not only is it expensive to purchase or rent, but its upkeep costs are high. If a second generation computer is bought or rented instead of a third generation one, the initial costs may be lower. Monthly maintenance costs, however, will be higher. Furthermore, costs for systems analysts, programmers, and computer operators easily can exceed the equipment costs. On top of these, one must consider air conditioning and other costs associated with a computer installation.

In the United States, with its relatively high labor costs, many computer installations have not resulted in net savings. Thousands of such installations anticipated such savings, but few achieved them. In less developed countries, where labor rates are low, there is much less chance of any real savings. Furthermore, transportation costs for the computer and import taxes (if any) lower the possibility of justifying a computer on the basis of savings.

If a computer cannot be justified on the basis of savings, possibly it can result in increased income, which more than offsets added costs. This would be true if the added expenditures associated with the computer were less than the selling price of the products of the computer. Here one must be sure that all costs are considered and that there is a relatively certain market for the products at the prices used in the justification.

Aside from monetary factors, it is possible to justify a computer if the equipment will perform functions which could not be done without a computer. The questions to be asked here are:

—Is it necessary to do them?
—What is their value?

Too often a computer is ordered for various non-quantifiable reasons, when the real purpose is to get a status symbol. It is a very expensive way of achieving status.

## Guidelines

Officials in developing countries faced with the question of whether to go over to a computer in a particular field might well ask themselves the following eight questions. Unless the officials can answer with an unequivocal "yes" to all of these questions it is very probable that the computer should not be used. With the difficulty in answering "yes" in many of the less developed countries, it is probable that the installation of a computer will cause more problems and cost substantially more than a manual or semi-automated system. The country will fare better with an improvement in the manual system and/or the use of some of the more simple types of automated equipment.

1. Is the decision to get a computer based on quantifiable facts?
2. Is a data processing manager with sufficient background in computers available?
3. Is there a ready source of people with experience in the technical areas of computers available within the country?
4. Are the power sources reliable and relatively stable?
5. Will the manufacturer or some other reliable source maintain the computer?
6. Will the guaranteed response time for maintenance calls be sufficiently rapid?
7. Is there another computer available and suitable for effective backup for the computer?
8. Considering all cost elements, will the computer-based system be cheaper than the manual or semimanual system?

There is no doubt that the computer is currently an attractive status symbol throughout the less developed world, and its desirability on this ground needs to be offset. While it was the status symbol in the more developed countries, bitter experience has proved it to be an extremely costly one. This disillusionment has occurred even though higher wage rates in the developed countries tend to make computers a more attractive and economic alternative. The less developed countries cannot afford to make the same mistake. There should be no higher status symbol than the achievement of an efficient operation incorporating a high level of employment and continuing employee development.

[Excerpted from "Computers in Less Developed Economies," Finance and Development. Washington (D.C.): International Monetary Fund and the International Bank for Reconstruction and Development, Vol. 8, No. 1, March 1971, pp. 2-6.]

# Book Review

Marketing and Economic Research Bureau, Economic Impact of Computers in India—A Survey. New Delhi: published by Surrinder Chanana for the Marketing and Economic Research Bureau, 1971; 66 pp.

There were 126 computers installed in India as of mid-1970, by far the largest number in any developing country. The Marketing and Economic Research Bureau, a private organization in New Delhi, undertook a factual survey of computer uses and results by means of a rather detailed mailed questionnaire, followed by interviews in a few cases; 53 computer users responded and supplied much useful information of a sort not previously available for developing countries. It is worth noting that all of those who replied to the questionnaire spoke in generally positive terms of their experience with computers; any adverse experiences, which must surely exist among 126 users, are therefore to be found among the 73 non-responders who did not contribute to the results described in the book.

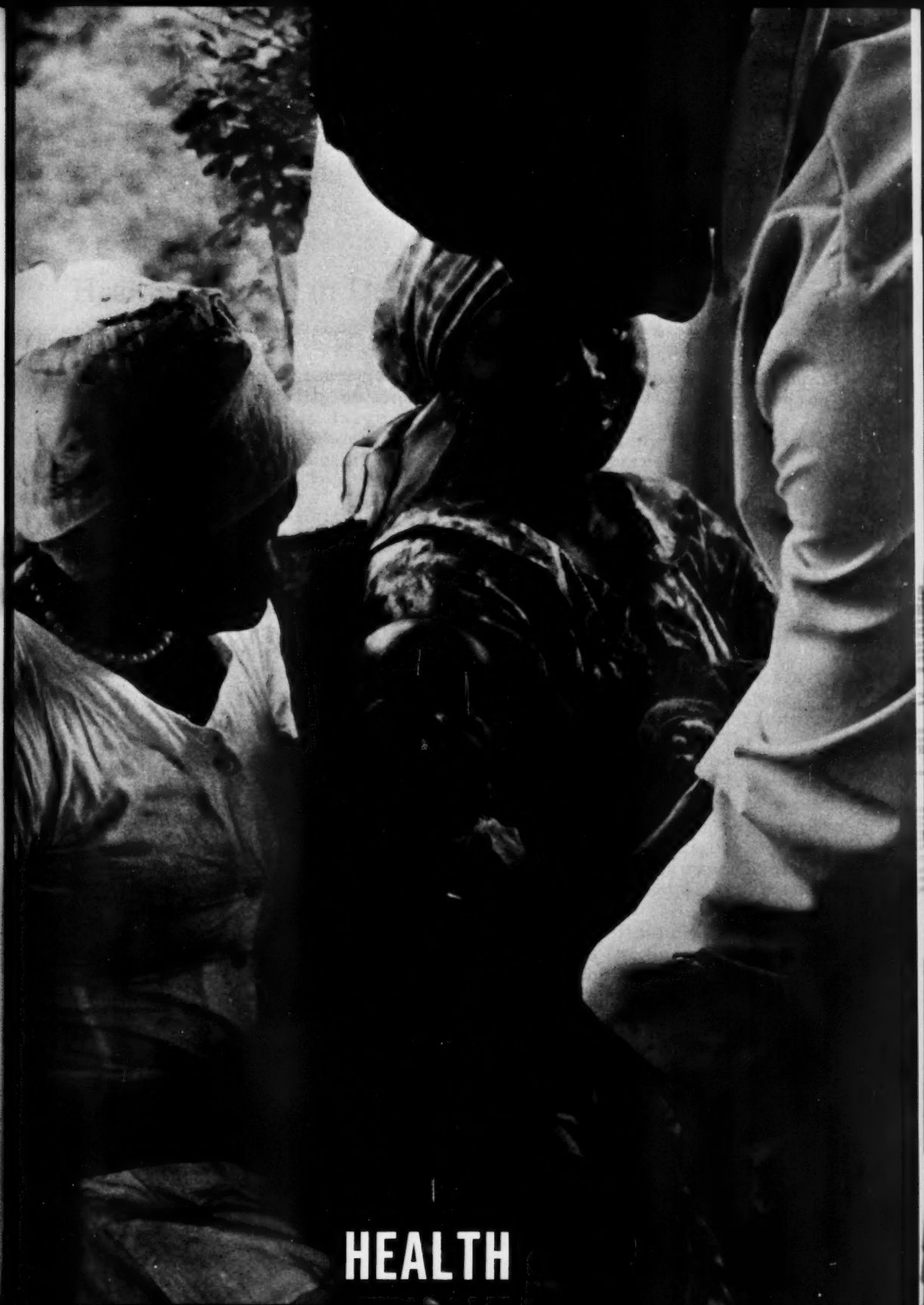
The first computer was installed 20 years ago at the Indian Statistical Institute. The numbers grew slowly at first, with only 15 in use by 1964. But in 1965, 17 more were installed, and new installations have continued briskly to date at around 20 per year. By 1970 there were 92 industrial users, of whom 40 were in the public sector; another 34 computers were employed for research and education, mainly in government institutions. Of the total, about half (67) were in three large cities, Bombay, Calcutta and Delhi, with another 21 in three second-echelon cities; a surprising 38 were scattered through smaller centers.

All of the 32 industrial users who described their types of computer application mentioned statistical analysis and management information, and also some kinds of accounting and administrative uses (including billing); these were followed in frequency by inventory (26 cases) and production planning/control (11). All of the research group who responded mentioned scientific computation; half of them also spoke of "management science" applications. It would appear that many of these computers are quite heavily used: of those where

there are data on shifts, 9 are used on one shift, 26 on two, and 11 on three shifts; the number of days per month, when given, ranged from 21 to "all" with a median of 25. The questionnaire, however, did not ask about down time, so these figures presumably refer to operation in the absence of trouble or repairs.

On the sensitive question of computer impact on employment, the reported results were almost all positive. Twenty-three users supplied personnel numbers in computer-related work before and after computers were installed: in 14 cases the pre-computer numbers were zero, so increase was inevitable; in 8 other cases increases were noted, ranging from 2 to 39; the State Bank of India reported a decrease from 418 to 350, but stated that other jobs were found for the 68 displaced. These reported increases reflect a counting of persons either in new activities or in narrowly defined activities that expanded with computer use. They indicate that computers do create new jobs, but they do not (with the one exception) seem to supply data showing whether computers are labor-displacing on balance compared to alternative methods for the same functions. A reluctance on the part of computer users to expose themselves in public to such comparisons is understandable.

The positive thinking displayed in these results becomes more significant when we turn to the reasons given for adopting computers and the observed gains in productivity. Computers were adopted to improve efficiency or productivity generally, to save time or speed service, and (in 19 cases) to do jobs which could not be handled manually; others mentioned intensified research (12) and improvements in reliability (10) or communications (5). Similar categories are mentioned in the observed results. Most interesting are the specific case histories, some of which are as follows: two electric companies reported speed-up and cost saving in billings, improved service, better control on unauthorized users of power. A locomotive plant stated that better inventory control had cut inventories by 10 percent and reduced capital needs by 50 million rupees. Others stressed cost reductions and speed-up in accounting and payroll operations, facilitating financial reports and giving employees better information on their earnings. An insurance company specified a number of improvements in paperwork. In research and engineering, six users spoke of projects not possible without the computer, and nine of acceleration in research; there were seven cases of computer-based curriculum development. In structural engineering, one center described cost reductions in five complex design activities to one tenth or one twentieth of the cost without computers, mainly by time saving.



# HEALTH

DOCTOR EXAMINING BABY AT WESO HOSPITAL, KENYA
[ PHOTO: WORLD HEALTH ORGANIZATION]

# Health Planning in Developing Countries

Oscar Gish

[Health care in poor countries with limited resources and trained manpower must rely heavily on small rural health centers which can reach the majority of people; large hospitals with costly equipment and specialized personnel should be de-emphasized. Many of the diseases prevalent in these countries can be effectively countered by this approach.]

There are three most basic reasons why planning for health care in rich and poor countries must be radically different. Firstly, there are the different levels of resources available to rich and poor countries, in money as well as skilled manpower. In 1969 the United Kingdom spent about $100 per head of population to keep its National Health Service operating. The United States spent some $300 per head for health services in that year. By contrast, Ethiopia spent around $0.50 for the health care of each of its 22 million people. The expenditure for health in Britain represented about 5 percent of the country's gross national product (GNP); the Ethiopian expenditure represented perhaps 0.6 percent of that country's GNP. Even if the Ethiopian expenditure for health care were to be multiplied to a figure equivalent to Britain's 5 percent of GNP, total expenditure for health care would then only be around $3.00 per head.

Differences in the availability of financial resources are also reflected in the statistics for hospital beds in rich and poor countries. While there are 10 hospital beds for every 1,000 of the population in the United Kingdom, there are less than 2 per 1,000 in Mexico and only 0.4 per 1,000 in India. The disparity in the number of available medical workers is no less great. In the

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United Kingdom there is one doctor for every 860 people, but there is only one for every 5,000 in India, one for every 13,000 in Haiti, and one for every 30,000 in Nigeria. Also to be taken into account is the fact that doctors are much more evenly spread, relative to population, in countries like Britain than they are in countries like India, Haiti or Nigeria.

A second basic reason for the need for different types of health planning in rich and poor countries is the differing structure and location of populations. In a developing country a third of the population will be under 10 years of age, two or even three times the percentage to be found in most industrialized countries. Another basic factor will be their rates of increase. In most economically richer countries population is increasing at 0.5 to 2 percent per year. In poorer countries the increase is more likely to be nearer 2.5 percent, or even 3 percent. The places where people live are also very different: rural areas are likely to hold 50 to 90 percent of the population of developing countries, but in the United Kingdom only 5 percent of the population is classified as rural and in the United States only 10 percent. In addition, the rapid rate of urbanization in poor countries presents special problems. With urban areas increasing at around 6 to 8 percent per year the growth of "shanty towns" (bidonvilles, favellas, callampas, etc.) is of particular importance.

A third basic reason for approaching health planning differently in rich and poor countries is the existing disease patterns, which differ drastically in the two types of countries. There are so many children, and their disease patterns are so inadequately cared for, that half or more of all deaths in developing countries occur in children under 5 years of age. In the United States, by contrast, over half of all deaths are caused by diseases of the heart and blood vessels, primarily among people between 50 and 70 years of age. In developing countries infant mortality (0-1 year) may be four times as high as in industrialized countries, while childhood mortality (1-4 years) may be more than forty times as high. Children in poor countries typically die from diarrhea, pneumonia and malnutrition. The diseases of the developing countries are largely the result of poverty.

Resources: Facilities

In rich countries the focus of health care has been gradually shifting away from the family doctor or general practitioner to the hospital and hospital-based specialists. This process has not been an easy one and its desirability has been called into question. Desirable or not, it must be recognized that the massive shift to hospital-based medical care is of fairly recent origin and is coincidental with other aspects of change consequent upon economic development. In most low-income countries the same sort of hospital-based medical care systems are being established (or at least the aim is to establish

them). In the absence of substantial economic development, however, such hospital-based systems are making impossible the spread of essential health services to the mass of the population. It is not unusual for the capital costs of a large capital city/regional type teaching hospital in Africa to be greater than the entire annual health budget of the country. The cost per bed in such circumstances may very well run upwards of $12,000 and that in countries with incomes as low as $70 per capita.

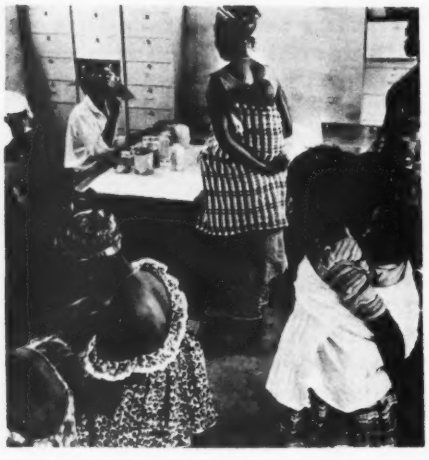
In principle, teaching hospitals in the capital city function not only as the teaching base for the medical school (as well as being centers of research), but also as the peak of a medical care referral system; patients from all parts of the country are sent upwards along a health care chain which starts with aid stations or dispensaries or health centers, then moves up through rural and district hospitals, and finally ends with the capital city teaching hospital. Hospital-based medical care and the hospital referral system are, however, likely to work only to a very limited degree. For instance, in Ghana it is estimated that fully two thirds of the population are not effectively covered by government curative health services, which have been primarily available only at hospitals. The inadequacy of the hospital-based referral system may be illustrated by data drawn from New Mulago Hospital in the Ugandan capital of Kampala. In 1964, of all admissions to Mulago, 93 percent came from the Mengo district in which Kampala is located; excluding obstetric and gynaecological admissions, 98 percent of which were from Mengo, the figure is brought down to 88 percent. Clearly then Mulago Hospital, at least in its curative work, is primarily serving as a district hospital (like most others of its kind), and not as a truly national health center.

Rural and district hospitals need not be as expensive as teaching hospitals. A bed in a teaching hospital in Africa will cost about $12,000 and a bed in a district hospital perhaps $5,000. A rural hospital bed will cost only half to three quarters of that figure. The cost of equipping and running various types of hospitals follows closely their capital costs. Not only will the larger, more expensive hospital have a higher running cost due to its size, but the cost will be proportionately higher than for the smaller institution. One major reason for this is that a teaching hospital will have more specialists on its staff, more general duty doctors, more registered nurses, and so forth, than will district or rural hospitals. The more capital-intensive a hospital is, the more skill-intensive it is likely to be.

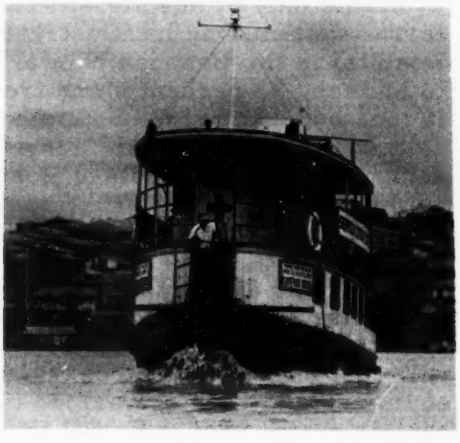
Poor countries (if not rich ones as well) concerned with reaching the whole of their population with a health delivery system must find an alternative to a system which depends upon hospital beds costing from $2,000 to $12,000 each. That alternative is a health delivery system which reaches the population at the lowest possible level. The accepted way of reaching large rural populations is through the health

center with its outlying aid stations or dispensaries. The health center aims to provide the entire health requirements of a family except those which can only be provided in a hospital. A health center in Africa can be built for somewhere around $50,000—the cost of four beds in a teaching hospital—and can provide most of the health care requirements for roughly 20,000 people. In a country like Zambia, 250 health centers, enough for the entire population, could be built at the cost of the new teaching hospital in Lusaka. The recurrent costs of such a health center are not likely to be more than $25,000 per year, or $1.25 for each of the 20,000 people covered by the center. Thus, a country with only $1.25 per capita to spend for health care could still provide basic health care services for its entire population.

Properly staffed, a health center can supply at little cost much of the medical care required by the people of a developing country. Many



Left: Mothers at maternal and child health clinic, Africa. [Photo: United Nations]



Above: Floating health center for isolated communities along the Amazon, Peru. [Photo: World Health Organization]

Left: Public health nurse makes case entries for patients waiting at health center, India. [Photo: U. S. Agency for International Development]

of the diseases from which they suffer are what might well be termed "health center diseases," that is conditions which health centers are well able to prevent or treat. They include the prevention through immunization of measles (one of the most important killing diseases in many developing countries), tuberculosis, poliomyelitis, smallpox, and whooping cough; and through the health education of their mothers, the prevention of the widely prevalent malnutrition in childhood. Most cases of many common diseases can also be readily treated in these centers; among them patients with leprosy, tuberculosis, pneumonia, gonorrhea, diarrhea and dehydration especially in childhood, malaria and hookworm infection. Health centers can provide family planning services, antenatal care, care of the normal delivery, child welfare facilities, school clinics, advice on environmental sanitation, and curative clinics for a wide range of important diseases. Health centers do not have operating theatres, X-ray plants, or more than minimal laboratory services, nor can they provide a doctor's opinion, so one case in a hundred has to be referred to a district hospital. Common among these cases are the abnormalities of labor and the consequences of trauma, particularly from accidents on the road. A district hospital in its turn has to refer about 1 percent of its cases to a regional or national hospital for specialist opinion or special facilities.

This account of health center services is, of course, oversimplified in that it assumes an evenly (and conveniently) spread population so that each health center can cover its required number of people. Many countries, however, have very low population densities with people either scattered in small villages or perhaps even nomadic. Such situations are usually best met with systems of aid stations and mobile clinics run from health centers.

Assuming that the generalized health center service does cover a country fairly well, it is still necessary to provide certain specialized hospital services in addition; these necessary services do not include radiotherapy, neurosurgery, cardiac surgery, artificial kidneys and organ transplantation. Not having these kinds of services does, however, raise the question of what to do with people who need them, perhaps because they are senior civil servants whose needs become known and identified. In one African country (Zambia) there is a "civil servants extraterritorial medical aid society" whose members insure themselves for the provision of these services abroad. The kind of hospital services required in poor countries must be provided in what are usually known as district hospitals, even if such hospitals have to be built in an urban environment. In large cities a number of district type hospitals can be located in the same city to provide sufficient scope for teaching and for many research purposes. A crude estimate would indicate that for $1.25 per head it would be possible to run a network of such hospitals so as to cover an entire population. However, this would mean spending $2.50 per person ($1.25 for health

centers plus $1.25 for hospital services) for health care instead of the $1.25 now being generally spent in Africa or Asia. The choices would then be either to reduce health center or hospital coverage, or to raise expenditure on the health services. For a country with a per capita income of, say, $100, to spend $2.50 per head for health expenditures or 2.5 percent of GNP would not be unreasonable.

Resources: Manpower

The kind of facilities employed for delivering health care are critical in determining the type of manpower employed. Large capital city hospitals of the type discussed earlier require specialists and other highly qualified manpower if they are to fulfill their roles properly in specialized medical research, teaching of highly qualified manpower, and the care of patients suffering from the one tenth of one percent of health problems which cannot be adequately handled in smaller, simpler institutions. In many developing countries there are not sufficient staff to man the large hospital facilities which already exist. Ethiopia has, for example, built a large new hospital for teaching purposes without any immediate prospects for staffing it. In this connection it is worth noting that in Africa the number of doctors per head of population had actually declined between 1962 and 1965, as a study of 13 Francophone and 13 Anglophone countries has shown. In 1965 there were three of these countries with one native-born doctor for less than 20,000 inhabitants, nine with one to 20,000-50,000, 11 with one to 100,000 and more, and two countries with not even one indigenous doctor. Even these figures do not show the real situation because of the concentration of medical personnel in the capital cities. In 11 African Francophone countries in 1965 about 60 percent of the indigenous and 50 percent of the expatriate doctors were located in the capital cities.

Health centers, in contrast to hospitals, can be operated by a variety of men and women with middle level skills, even in the virtual absence of anyone with a university education. In general, the various types of medical auxiliaries make up a skill continuum which extends from those with very little education and training (say six years of schooling and virtually no training), to those with complete secondary education plus a number of years of training. Para-medical staff should not be confused with auxiliaries: the former include registered nurses, pharmacists, laboratory technicians, health inspectors and other such staff who are fully qualified professionals. They usually do not, however, have the university education required of doctors, although their international status is usually recognized. The medical assistant is the key auxiliary. He is the major provider of primary medical care in many African and Asian countries. For example, in Kordofan Province in the Sudan there were 2.1 million inhabitants in 1969. This population was served by 36 doctors located in 12 hospitals; there were also 81 medical assistants in 81 dispensaries, and 126

qualified nurses who are providing the bulk of the health care for the people of Kordofan Province.

At present the Sudanese medical school in Khartoum is producing 30 graduates per year. The education of these medical students is virtually indistinguishable from that of medical students in, say, Britain; that is, medical education is very much in tune with hospital-based practice and entirely consonant with employment in a large city. At present over a third of all Sudanese doctors work in the capital city where about 5 percent of the population live. In future the increased output from the medical schools is likely to find itself concentrated in the capital city to an even greater extent than at present. This phenomenon can clearly be seen in countries in the Middle East and Asia (e.g., India, Pakistan, Iran) which have been rapidly increasing their output from the medical schools and still see no significant increase of doctors outside the capital cities and other large towns. In time, as the larger cities become saturated with medical men, some will have to move to the smaller centers. But perhaps an even greater number will escape from the burden of excessive competition in the cities by emigrating to another country altogether. In the United States there are already 25,000 medical graduates from schools in developing countries, and in Great Britain there are close to 10,000 doctors who were born in Asia and Africa, primarily the Indian sub-continent. Canada, Australia, Germany and France have also become the beneficiaries of medical personnel born (and usually trained) in the third world.

The medical "brain drain" from the developing countries is an extension of the general problem of providing medical education and health manpower planning which is suitable for the conditions of poor countries. If doctors are trained in postgraduate specialities, of which poor countries can support relatively few practitioners, it is inevitable that numbers of them will emigrate. The crux of the problem is whether to train doctors for the needs of the mass of the population who are rural dwellers, with low effective economic demand, or for those relatively few urban dwellers who have a high effective economic demand. If international emigration of doctors is an extension of the rural-urban migration problem, the type of medical education that will forestall international emigration is also likely to increase the number of doctors working in the countryside.

If 80 percent of the population is rural, then 80 percent of the medical students should be educated accordingly. Because the causes and preventions of illness, disease, and death differ in rural and urban areas, the 80 percent or so of doctors who should be preparing for work in rural areas must come to know the causes that are connected with rural life, and consequent prevention of illness, disease, and death. Successful medical education, intended to produce doctors for rural areas, should be oriented towards work in those areas and new

curricula need to be designed for such purposes. Two corollaries which follow from the above are: 1) the desirability of producing a doctor with the minimum (and therefore the least expensive) training necessary to fulfill his duties; and 2) the need for at least part of his medical training to be carried out in the circumstances of a district hospital in the countryside. It is too late after medical education has been completed to change substantially the pattern of a doctor's life. If medical training has prepared a doctor only for medicine as practiced in a multimillion dollar teaching hospital which accustoms him to expect facilities which cannot be reproduced elsewhere in his country, and which disenchants him fromsubsequently working in a district hospital, then he must either practice in his country's capital city or go abroad. Tax and housing incentives would be among the essential means for drawing doctors to the countryside. Still more essential are active health centers and good and interesting professional conditions in the rural areas. Travel, promotion and honors should go to the rural medical workers in recognition of their important work. Needless to say, the national health budget should be allocated fundamentally in keeping with the nation's population distribution. It is, however, suitable medical education that can lay the basis for keeping doctors usefully employed in their home country. Part of the process of suitable medical education is a suitable selection process.

Another very relevant factor is that in a developing country one of the doctor's main roles is to act as teacher, supervisor and consultant to a team of auxiliaries. He will be most often required to fill this role by supervising a series of health centers in the rural areas or by running a district hospital, and this not only for a year or two after qualification but for the majority of his professional life. These teams of auxiliaries should be part of a health center service (under a Director of Health Center Services) which would act as the basic carrier of health services in the country. Such a service would be the base upon which all other health care in the country would rest.

Population: Structure, Location and Growth

The populations of developing countries are young, rapidly growing and still primarily rural in spite of rapidly increasing urbanization, characteristics which give rise to special health care considerations. The diseases of children in developing countries are particularly amenable to prevention (in contrast to cure). The major killing diseases are the group of childhood diarrheas, pneumonia and protein-calorie malnutrition (PCM). Following behind these "big three" are tuberculosis, anemia, intestinal helminth infections (worms), measles, whooping cough, malaria and accidents.

The nature of these diseases, coupled with the age structure and high rurality of the population, would support the view that the health center and the medical assistant are most suited to be the basic in-

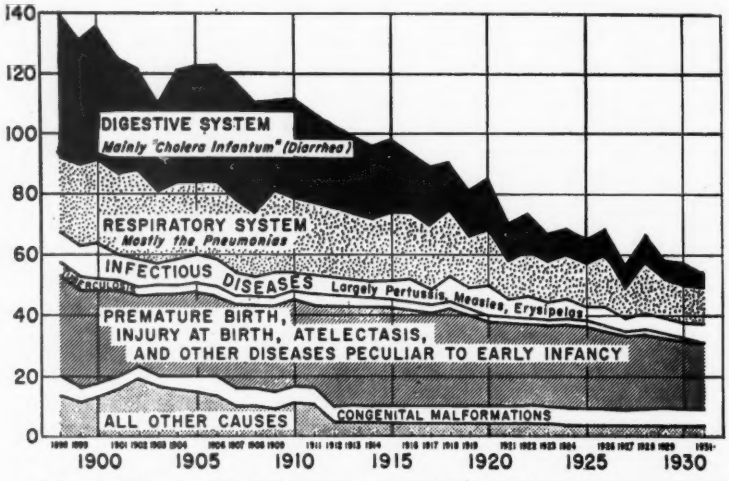
struments upon which the health services must rest. Not only can health centers fit more closely into the rural health situation as well as general rural environment, but they offer an appropriate base for family planning work within the context of material and child care activities. Maternal and child health care can be best carried out close to or within the home environment of the women and children—that is, mainly within villages. An exhibition of slides showing the dangerous diseases borne by mosquitoes or snails which is seen in a two-room mud dwelling belonging to one of "us" takes on a significance which cannot be achieved in the context of a large impersonal hospital building which belongs to "them."

The special problems connected with rapid urbanization must also be kept in mind. The crowding together of large numbers of people into small insanitary areas has placed intolerable strains upon the health and social services in the towns and cities of developing countries. Probably no other measures could do more to improve the situation in the urban slums than the provision of fresh water in adequate quantities, proper sewage disposal systems and generally improved sanitary and hygienic conditions. Beyond these, there are all the social services necessary to deal with conditions which are making for increasing venereal disease, mental illness, and other social illnesses in the context of the growing slum areas which threaten to engulf many of the towns and cities of Africa, Asia and Latin America (and more than a few in Europe and North America as well).

## Disease Patterns and the Road Ahead

The type of diseases to be found in tropical countries are in the first instance to be treated as aspects of poverty rather than of the tropics. This point can be illustrated by data drawn from the medical history of New York City. Throughout the nineteenth century the death rate in the city remained constant at about 30 per 1,000. A substantial part of that death rate was due to a level of infant mortality which was not unlike that to be found in developing countries today. As shown in the following graph, the first three decades of this century saw a dramatic decline in infant mortality in New York City from 140 per 1,000 to less than 60 per 1,000. Of that fall, two thirds occurred in the "diarrhea-pneumonia" complex of childhood diseases.

The most striking aspect of this rapid fall in infant mortality is that it occurred before there were any antimicrobial drugs or vaccines to treat this particular disease complex. The striking decrease in mortality resulting from control of the diarrhea-pneumonia disease complex in New York City was accomplished through a series of measures taken early in this century. Some of the specific public health developments of the period included an improved water supply, better control over quality and distribution of foodstuffs, and the creation of visiting




Infant mortality by prominent causes in New York City (rates per 1,000 births)
Source: *Weekly Reports of the Department of Health, New York City*, Vol. XXI, no. 50, p. 396, December 17, 1932. See reference 6.

nurse services and well-baby clinics. This period also saw the growth of pediatrics, major campaigns against illiteracy, and a substantial increase in primary schooling.

The specific set of measures taken in New York City at the turn of the century are not necessarily relevant to all, or indeed any, of the countries in Africa, Asia or Latin America today. What is clear is that the road leading to the reduction of morbidity and mortality is not necessarily paved with advances in medical science. In fact, the technological possibilities inherent in the already existing stock of knowledge about the causes, prevention and cure of disease is far greater than our social and political (not to mention economic) ability to utilize those possibilities fully. The road to the reduction of morbidity and mortality is more likely to be paved with social and political advances, which are reflected in an improved system for the distribution of health services, than with further advances in medical science as such. This is probably not only true for poor countries, but for rich countries also.

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# Health Planning in Latin America

Dieter K. Zschock

[Health planning and action programs have made progress in Latin America in the 1960s despite inadequacies in their methods, and a few surveys have brought out significant new data on needs and conditions. But problems persist; new thinking is needed and economic analysis could add much to the effectiveness of health planning.]

The governments of Latin America, having been preoccupied mainly with industrialization since World War II, began to give more attention to social development during the 1960s. Priorities of development policy, stressed under the Alliance for Progress, now include education and health; analyses of Latin America's human resources, however, have concentrated mainly on manpower requirements and corresponding educational needs. They have been supported by evidence of high returns to investment in education, while studies of the region's health conditions have yielded no comparable evidence in support of health sector investments. Health improvements are evident, but analysis has not yet shown to what extent they are attributable to health expenditures alone. Poor health is closely associated with poverty, low education, and rural residence, but causal relationships among these and other variables remain largely unexplored.

## Health Planning in the 1960s

From 1890 until the formation of the Alliance for Progress at the outset of the 1960s, the inter-American system of cooperation retained its predominantly peacekeeping and mutual defense orientation. The Charter

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of Punta del Este in 1961 for the first time urged improving health for both economic and social development. It signifies agreement to include "indices of infant mortality, illiteracy and caloric intake" in evaluating relative development internationally, together with data on per capita output and income. The Charter's principal health goal is an increase by five years of life expectancy at birth, including a 50 percent reduction in mortality under five years. To this end, the Charter proposes targets of providing potable water supply and sewage disposal facilities for at least 70 percent of the urban and 50 percent of the rural population. In more general terms, the Charter speaks of eradicating malaria, controlling communicable diseases, improving nutrition, expanding medical care coverage, training medical and health personnel to meet at least minimum requirements, and intensifying scientific research. The 1967 Declaration of the Presidents of America gave renewed priority to low-income groups in the expansion of environmental sanitation and nutrition programs and added the promotion of intensive maternal and child welfare programs as a new health sector priority. But the quantitative dimensions of the Charter's health goal were arrived at rather arbitrarily; at best, they reflected an educated guess of what might be attainable if past trends continued into the future. Measures required to attain the specified reductions in mortality were recorded in similarly arbitrary fashion.

Under the Alliance, the governments nevertheless agreed to prepare national health plans immediately. The Alliance specified that an inter-governmental task force on health should be organized through the Pan American Health Organization (PAHO), which has provided technical support for health programs in the Americas since 1902. Under PAHO auspices, the Task Force brought together the region's ministers of health for two conferences during the 1960s, elaborated the health goals of the Alliance, and helped strengthen national commitment to implement measures to attain them. The first conference of health ministers, held in 1963, emphasized that health is an investment in economic development as well as in social progress. The conference called for epidemiological investigations, analyses of health services, and the development of reliable statistical data as prerequisites for establishing health program priorities. (The Colombian health survey, reviewed below, was initiated as a pilot study in response to this call for research to improve the data base.) At the second conference in 1968, while reiterating previously stated health objectives, the ministers revealed the failure of their countries to incorporate health plans into national development plans, although some progress in data gathering was acknowledged.

With the hindsight of the second conference, one may view a health planning method developed under PAHO auspices in 1963 with some skepticism. This method has been taught to some 200 high-level health professionals in international courses given at the Latin American In-

stitute of Economic and Social Planning in Santiago, and in national courses to over 2,000 health professionals at lower levels of program administration. The method, in essence, seeks to measure the costs of reducing preventable diseases, and then to calculate the benefits in terms of reductions in mortality. Some functional problems in this approach are: the unreliability and insufficiency of data on disease incidence, the likelihood that illness and death in most cases have more than one cause, and the failure to take account of morbidity in the planning process. However, there have been positive effects of national health planning under PAHO in dramatizing health problems and probably in improving resource utilization.

In 1968 PAHO published a succinct account of health improvements in the 1960s. The report concludes that "infant mortality is not being decreased at a pace to meet the goals of the Charter of Punta del Este," but that "mortality in the age group 1-4 years has decreased rapidly, approaching the goal of the Charter." It attributes the reduction in child mortality largely to improvements in environmental factors, principally better nutrition and sanitation. This conclusion suggests, for example, that health improvement may be a consequence of development more generally, rather than being attributable primarily to maternal and child care. Progress in malaria eradication has been impressive, and achievements in the control of communicable diseases are encouraging. The latter findings undoubtedly represent benefits attributable to expenditures on disease control. In providing homes with toilets and running water, the target for urban areas of 70 percent has been achieved, while rural areas lag far behind the 50 percent target set in the Charter. Coverage by medical care remains biased in favor of urban residents.

## Reform of Medical Care and Education

Although responsible for health planning, ministries of health in Latin America have had very little authority over medical care. Most countries in the region have a number of different and uncoordinated systems of health services, as is usual in most parts of the world. In addition to public health services and private medical care facilities, they have separately organized social security services for salaried employees and for wage earners, quasi-public charity hospitals (governed by boards of private citizens or church authorities, and financed by donations and income from state lotteries), and special facilities for military and police forces. Many national, regional, and city government agencies operate independent medical care services for their employees and others. Moreover, all private facilities except charity hospitals serve relatively small, privileged segments of the population. Large segments of the countries' low-income population, particularly in rural areas, receive few if any modern health services. Colombia and Argentina have initiated reforms that assign a central

role to the coordination and expansion of medical care by their health ministries. In other large countries, such as Brazil, Venezuela, and Mexico, which have similarly uncoordinated health services, no such reforms are as yet in evidence. But a new generation of leaders in medical education, with overseas training, is groping to reconcile its professional orientation toward specialized and research-oriented medicine with a growing tendency to regard medical care as a means of economic development and social progress.

A recent survey, sponsored by PAHO, shows the distribution and characteristics of medical schools in Latin America. The region has 151 medical schools (of which 69 are in Brazil and 22 in Mexico) with a total enrollment in 1967 of 98,245 students. Argentina had the largest number of medical students, 27,790, but only nine medical schools; Colombia also has nine medical schools, but had only 3,572 students enrolled. Medical education in most schools follows immediately after secondary school, although in several schools, one or two-year preparatory "general studies" programs are being introduced to improve the preparation of applicants. The length of medical curricula vary from five to seven years; retention rates of students are generally low; and the quality of schools, especially among the many schools in Brazil, varies greatly. The survey report echoes the recommendations, made by many analysts and leaders of medical education in Latin America, to restrict admissions, introduce general studies programs, and change medical education from a theoretical to a community health services orientation.

The principal vehicle for discussions of reform in medical education has been a series of regional meetings, beginning with the Pan American Congress on Medical Education in 1951, and leading in 1962 to the founding of the Pan American Federation of Associations of Medical Schools. In 1966, the Federation sponsored its First General Conference on Medical Education, which stressed the relationship between medical education and social and economic development. It remains unclear, however, to what extent the quality of medical education is in fact being improved and whether students are indeed turning their interests to community medicine as a result of high-level interest in reform. Personal observation in Colombia and Chile, for example, leads one to be optimistic; some of the developments elsewhere, however, suggest uncontrolled and uncoordinated activity.

## Significant Surveys of Health Conditions and Services

Health planning and programs undertaken by national governments rely on vital and health statistics, the sources of which are generally unreliable in most countries. But several efforts to improve both the data base and health planning, undertaken as special research projects in the 1960s, are noteworthy.

1. The Inter-American Investigation of Mortality. A comparative study of causes of death in urban areas was made under PAHO auspices in 12 cities, 10 of them in Latin American countries, plus San Francisco, U.S.A., and Bristol, England. Field research, carried out during 1963 and 1964, consisted of samples of about 4,000 deaths in each city, whose causes were carefully established from available records, supplemented by interviews with medical personnel and family members who knew details of a deceased person's medical and personal history. The study included only deaths of adults between 15 and 74 years of age because least was known about causes of adult mortality.

Communicable diseases in the ten cities were found to account for fewer than 10 percent of all causes of death. Cancer and cardiovascular diseases, which are largely unpreventable, accounted for approximately half of all deaths in the survey. Preventable causes, on the other hand, accounted for roughly one third of all deaths; moreover, these causes of death were highly associated with adverse social and environmental conditions that affected the deceased. Preventable causes were especially prevalent in mortality of the 15-34 year age group where they accounted for 70 percent of all male deaths and 57 percent of all female deaths. The most frequent "preventable" causes of death among all males were alcoholism, accidents, and violence. Most frequent preventable causes of female deaths were abortion and cervical cancer. Far less frequent causes of death were the infective and parasitic diseases, which tend to be principally debilitating in their effects. Comparing its findings on urban mortality with national mortality data, the study concludes that in Latin America urban mortality is two to four times lower than rural mortality, due in part to the higher concentration of health services in the cities. Results of this mortality survey suggest some guidelines and conclusions for health planning. Most importantly, they suggest that relatively few deaths are preventable by conventional health program activities. Such programs may have their greatest impact among adult females if they provide family planning assistance and cervical examinations. Among males, prevention of alcoholism and violence as causes of death may be impossible without social and economic changes.

2. National Health Planning in Peru. The first major attempt to combine research, training, and health plan formulation under the Alliance was made in Peru in 1963/64. Before that time, health planning in Peru, as in most developing countries, was limited to substantiating international loan applications or attacking a defined health problem (e.g., malaria). National health planning occurred only in the guise of buttressing next year's budget request, with no serious attempt to coordinate projected requirements of many separate health projects. In 1962, Peru instituted a National System of Planning, as did a number of other Latin American countries, in direct response to

the call for such action under the Alliance. Central planning offices were created, supplemented by a coterie of sectoral planning units. Despite urgent demands to produce a national health plan in a hurry in 1963, the newly created health planning unit deferred work on the plan in favor of intensive staff training, and, in addition, training of 135 health officials in other public agencies concerned with health. Education and direct involvement were felt to be far more effective than fiscal or administrative controls. The health planning unit also undertook extensive field research, rather than relying on available statistics in formulating a national plan. Selecting three representative areas, with populations of about 200,000 each, in the three natural regions of Peru, the planning unit surveyed health conditions and available resources of health manpower and facilities to establish a data base. Upon this foundation of training and research, a five-year plan was formulated in 1965; plan implementation has been delayed, but interest in it has continued.

3. Study on Health Manpower and Medical Education in Colombia. In 1963 Colombia was selected for a comprehensive health sector analysis under the joint auspices of its Ministry of Public Health, the Colombian Association of Medical Schools, PAHO, and the Milbank Memorial Fund of New York City. The intent was to do a pilot study that could be readily adapted by other countries in the region. Principal objectives were to survey health deficiencies and provide guidelines for changing medical education in accordance with newly identified health needs. As its most ambitious project, the study carried out a national morbidity (illness) survey of a 3 percent representative sample of the population covering 8,920 households with a total of 52,964 members. In addition to detailed personal health information and vital statistics (including pregnancies, deliveries, and child mortality), the household interview also gathered data on family composition, occupation, education and income levels, and on housing conditions. Detailed clinical examinations of a 10 percent sub-sample provided validated morbidity data. Research also included a census of medical manpower (physicians and nurses); an analysis of current programs in medical education; an inventory of medical care institutions, including a partial analysis of their utilization; and a background review of socio-economic and demographic characteristics of the Colombian population. Following two international conferences in 1967 in which the results were reviewed and discussed, many of the findings of the study have been published in segmented summaries. These provide an extensive overview of Colombia's health problems and health services such as has never before been available.

The Colombian study found that health conditions are closely associated with residence, income, and education; morbidity survey data also furnish strong evidence of socio-economic inequalities in access to and utilization of medical care. About four in ten persons in low-

income families complained of illness at the time of the household interview, as compared with fewer than three in ten among the relatively affluent. Self-perceived illness involved activity restriction in about one fourth of all cases. Among the poor, about one fourth of those who felt ill consulted a physician or nurse; among the well-to-do who felt ill, almost half received medical care. Medical consultation, however, was associated still more highly with education than with income. At all levels of income and education, medical consultation was about twice as high in urban as in rural areas. With these findings, one might begin to develop indices of health services deficiencies, particularly among the low-income segment of the population.

In the clinical sub-sample, most frequently diagnosed were gastrointestinal diseases, which affect almost one fourth of the population, while stool examinations showed that eight of ten persons carry pathogenic parasites. Also frequent were cirrhosis and respiratory system ailments. Among children, for whom gastrointestinal diseases are the leading cause of death, six of ten suffered from serious malnutrition. Environmental conditions are closely associated with the incidence of morbidity and mortality. Only 69 percent of all urban and 49 percent of all rural households occupied a house or apartment; the rest occupied what are essentially slum dwellings. In urban areas, virtually all houses and apartments had inside toilets and water supply; in rural areas, over half of all dwellings had no water supply and three fourths had no toilets (inside or outside). These and related findings strongly suggest that poor health in Colombia is caused as much by unsanitary environmental conditions as by insufficient access to medical care. The attack on such health problems, therefore, requires improvements in environmental sanitation as well as medical care. Educational efforts by medical practitioners, in the schools and through public information, may also help to improve health conditions as long as costly programs to provide housing and sanitary facilities cannot meet the extensive deficiencies in these areas.

The distribution of medical care resources is biased toward urban areas and the relatively affluent. Nine out of ten physicians practice in towns and cities, which account for one third of the country's population. Very few municipal public health posts, which are the only source of modern medical care for most of the rural population, are permanently staffed by trained medical personnel. Of all consultations for medical care among the poor in rural areas, only about half represented contact with medical doctors and trained nurses, thus suggesting strong reliance upon indigenous midwives and healers. Registered and practical nurses, of whom Colombia had only 1,170 and 3,500, respectively, in 1965, are in shorter supply even than physicians, who numbered about 8,000. In urban areas, the supply of doctors probably satisfied effective demand and there is even some evidence of oversupply since a number of medical doctors do not work

full-time, or work in other occupations. The supply of registered nurses is low for two related reasons: nursing education requires graduation from secondary school; but the occupation has low social prestige among girls from affluent families, while few girls from lower income families graduate from secondary schools in Colombia. Although many doctors work in public health services available to the urban poor, the popular demand creates heavy workloads and public resources are insufficient to employ more doctors. More extensive use of auxiliary health personnel, for example, might raise the productivity of public health services.

Public health expenditures in 1961-65 remained a constant proportion of the gross national product (GNP) at about 1.8 percent, which, together with private expenditures, is probably below the 3 to 5 percent of GNP that more developed countries typically expend on health services. The expenditures for social security health coverage (some 30-40 percent of government health spending) primarily benefit employees of government and modern private enterprise, who represent only about 10 percent of the total population. At the other extreme, about 20 percent of the population, principally in the rural areas, is beyond the reach of even the most elementary medical care. This inequality in the distribution of resources available for health services, however, as well as the dispersion of health services among many uncoordinated agencies and activities, may be reduced if a reorganization of the health sector now under way is successful.

The Colombian Ministry of Public Health lately has been assuming control over a broader spectrum of public health activities with the help of legal reforms introduced in 1968. It plans to exercise this control principally as a regulatory and planning agency, delegating operating responsibilities to regional and municipal governments. In 1969, the government also decided to coordinate the utilization of existing and the construction of new hospitals, involving principally the Ministry and the largest social security agency. The Ministry has been using the findings of the national health study to dramatize the role of health in the country's development, and to stress the need for coordination and greater efficiency in the utilization of resources available for health services. A hastily prepared national health plan, however, did not make analytical use of health study findings to calculate health service deficits, nor to project health service requirements on the basis of either biological need or effective demand estimates. The planning process is now being further refined, however, with the expectation that it should involve annual revisions and thus become a perpetual effort to rationalize the allocation of resources.

While the study has demonstrated how a comprehensive data base can be created with relatively inexpensive survey and special census methods, it has failed to provide for the immediate utilization of this information for planning purposes. However, the experience gained

by the participating institutions and the many health professionals employed in the field work and analysis stages, as well as the national and international conferences held for the study, have undoubtedly created a better understanding of the dimensions of the country's health problems and, by implication, those of other Latin American countries. If this awareness can help orient medical education toward community medicine (and thus restrain its tendencies toward increasing speical-ization) and encourage the more efficient utilization and more equitable distribution of resources in health services, then the study's original objectives will have been largely met.

4. National Health Studies in Argentina and Chile. Following the Colombian example, Argentina launched a similar effort in 1967. The study's outline included the same topics as the Colombian study, only with a stronger emphasis on determining the sources and composition of health services funding. Chile launched a national health study in 1967, also in part supported by PAHO. In contrast to the Colombian and Argentine studies, which are principally data gathering efforts, the Chilean study, like the Peruvian study in the early 1960s, is an attempt to construct dynamic health planning models and to gather data specifically required for the models. The Chilean National Health Service already controls almost all public health activities, and public health services are now within reach of most of the country's popula-tion; the Service employs about 80 percent of all physicians and nurses. An important objective of the Chilean study, aside from pro-viding policy guidance, is to develop and test a dynamic health man-power planning model which would project health sector expenditures, help in detecting potential bottlenecks, and suggest where health serv-ices productivity might be raised.

## Economic Analysis and Health Planning

Health planning, an activity which has been dominated by medically educated professionals—in Latin America as elsewhere—could benefit from the application of social science concepts and methods. Economic analysis, for example, could make intersectoral comparisons of bene-fits derived from health expenditures with those from other economic and social development expenditures, as well as concern itself with activities within the health sector. It could also seek to distinguish between economic benefits (raising labor productivity) and social benefits (improving welfare through more consumption). Health plan-ning would then seek to allocate resources so as to maximize economic and social benefits in some normatively determined combination, both intersectorally and intrasectorally. In the past, Latin American public health programs have concentrated largely on providing such public goods as disease control, innoculations and (in rural areas) sanitary facilities. If they are now going to provide medical care for the indigent, the economic and social benefits deriving from such action

should be compared with productivity and welfare gains through environmental improvements in rural areas and urban slums.

Conceptual problems and data limitations are such that the contributions of economic analysis to health planning have so far been minimal. Three conceptual approaches have been pursued in studying economic aspects of health services. The first two are variations of cost-benefit analysis. One, examined by Mushkin, measures economic benefits in terms of productive time of labor gained by reducing morbidity and prolonging life expectancy. The other, exemplified by Weisbrod, calculates benefits in terms of health program costs avoided by investment in preventive measures. Both of these analytical approaches could be applied in Latin America. Mortality and morbidity data might be combined with research on labor productivity to yield results on losses in output, and one might estimate to what extent costs of curative programs could be reduced through greater investment in preventive programs. The third approach is oriented toward the calculation of health manpower requirements. The advantage that cost-benefit studies have over manpower requirements analyses is their relevance to the justification and allocation of health expenditures; the identification of manpower requirements typically fails to consider them in the context of economic constraints. The Peruvian and Chilean studies, however, are attempts to take account of economic constraints, among other determining factors, and these are the only systematic efforts so far in Latin America to gear analysis into operational planning.

None of the approaches and studies cited has attempted to isolate the effects on health of health services from those of other environmental factors. In a recent attempt by Auster et al. to estimate the reduction in mortality in the United States in 1955-65 attributable to four variables—medical care, education, income, and (urban and regional) residence—the authors concluded that "the effects on mortality of education are about double those of medical care." Furthermore, comparing marginal costs of medical care with marginal economic benefits in the form of increased production, they speculate that costs may have exceeded benefits in this narrow sense. Reductions in mortality alone, however, are an incomplete measure of benefits from health services; reductions in morbidity from these same health services would raise production benefits substantially.

Health manpower planning should concern itself with raising health services productivity and increasing the number and use of auxiliary medical personnel in order to expand health services coverage. Health manpower requirements involve some combination of biological need and effective demand calculations. In developing societies, the former far exceed the latter, and it remains for public health officials and public policy makers to compromise on what constitute minimal re-

quirements, given the resources available for health programs. At any given level of resources available for health, a range of options exists of how to allocate them equitably and utilize them efficiently. Health manpower planning models might contemplate the substitutability of capital for certain types of labor (for example doctors, if they are scarce), as well as the substitutability of various types of health manpower. In addition, the effects on mortality and morbidity of medical care and other health-related investments such as disease control, environmental sanitation, housing, health education, and nutrition could be determined and compared in terms of their relative costs and benefits. Economic rates of return could also be compared with more easily calculated rates of return on public investments in other sectors such as transportation, construction, utilities. Analytical and technical problems would be formidable, but if health planning in Latin America is to progress beyond intuitive judgment, the effort must be made.

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# The Auxiliary in Medicine

N. R. E. Fendall, M.D.

[Medical auxiliaries are essential in developing countries to extend medical services to large segments of the population. The functions to be performed by various types of auxiliaries and the requirements for their training and status are outlined.]

My advocacy of the use of auxiliary personnel to expand and accelerate the delivery of medical and health services is directed primarily, but not exclusively, to the so-called newly emerging countries. The impediment to improving their standard and quality of life is not so much a lack of knowledge as the inability to apply it extensively enough. We know, for example, that vaccines, if not the ultimate answer to all communicable diseases, can reduce many diseases to a state of relative insignificance; yet many diseases for which vaccines exist are still widespread. We know that much disease can be classified under the term "filth diseases" for which environmental preventive measures are available. Many other diseases, such as leprosy, yaws and tuberculosis are susceptible to attack through prophylactic drug campaigns; others succumb to the residual insecticides. Yet these diseases still abound.

By the proper training and use of auxiliary personnel it is possible to achieve a much wider application of existing medical and health knowledge. If we are to make any impact on world disease and ill health it is essential to achieve a greater outreach, within the limits placed on us by severely restricted economic and educational resources and in the face of unlimited demand and need for service. Professional personnel

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are expensive, not only expensive to produce but expensive to employ: they demand high salaries, and the requisite professional and social environments have to be supplied as well. If a physician is trained to the concept of scientific clinical medicine, then hospitals with laboratory and radiological facilities, a full variety of pharmaceutical supplies, and well-trained supporting paramedical staff are all essential to his job satisfaction. In addition, one must provide an adequate social environment—housing, educational facilities, communications, and intellectual company. All these can be provided in the major towns but not in rural areas where the majority of the people in underprivileged countries reside. To attempt to persuade, induce, coerce and compel professionally trained personnel to accept positions without supplying these measures is to ensure failure and engender opposition.

The alternatives are usually stated in terms of the "philosophy of the best" which implies that from the very start one provides only for professional-quality personnel, commencing with small numbers and gradually increasing the flow until a total outreach is achieved. But experience indicates that the goal of a sufficiency of professional personnel is not obtainable under any circumstances—the goal keeps receding as standards, aims and knowledge increase. The diametrically opposed "philosophy of the most" starts on the basis of total outreach with personnel trained to an educational standard the country can afford in terms of its state of economy and general education. Over the years, as schooling improves, these standards are raised until professional competency is achieved. There is a third way, which is not a compromise but an amalgam of both. This is to have a two-tier level of trained personnel—the auxiliary to deliver the quantitative requirements and the professional the qualitative.

A clear distinction is needed between the role of the auxiliary working as an "assistant to" a professional and his role when working in a "substitute" capacity. Some societies may accept the auxiliary as a distinct possibility in the assistant role while rejecting him in the substitute role. As an assistant the auxiliary has a truly subordinate role with limited activities and limited responsibilities. He or she is always under close supervision and can be relived immediately if it becomes apparent that the task in hand is beyond his or her capacity. The assistant role is normally performed in situations such as the hospital ward, the operating theater, the labor ward, or the outpatient department.

In the substitute role the auxiliary is placed in a situation where supervision is remote, irregular or sometimes non-existent. The auxiliary then has a much greater range of functions to perform and, more importantly, a greater responsibility to discharge. In the assistant role it is the professional supervisor who makes the judgment

as to whether the auxiliary is capable of performing a particular function; whereas in the substitute role it is the auxiliary. He has then to decide for himself whether he can cope with a given situation or whether he must refer the patient or the problem to some more competent (and distant) person. This requires the same degree of responsible judgment that the general practitioner has to exercise in deciding whether he refers a patient to a consultant physician. It is also an exercise in humility and restraint that requires considerable fiber. The substitute auxiliary is also in the practical business of saving life. He must diagnose and act in many cases without waiting for further advice. The decision is his and his alone.

## Purpose

The purpose of the auxiliary is to overcome shortages of personnel. Shortages of trained professional and paramedical personnel are aggravated by maldistribution between rural and urban areas; the latter is the more important factor. If we restrict health services to high level manpower, then the maldistribution will only be corrected when populations will have become largely urbanized. Auxiliaries provide for a more extensive outreach of services for the quantitative demands at a level of cost that a poor country can afford. They also prevent a waste of highly skilled professional talent being occupied on mundane and routine tasks, while the more serious ills are neglected through lack of time.

The auxiliary being a much less educated person is nearer to the people he serves in thought, culture and way of life; he lives with a foot in both cultures—the traditional and modern. Because of this he is regarded as one of them and can communicate with them, while at the same time he is able to help them by his greater knowledge of their problems. Moreover, because of his lesser education he is more likely to be content with a less sophisticated way of life, and more content to remain in the rural areas.

With these purposes and roles in mind it is obvious that selection of trainee auxiliaries must pay more attention to character traits than academic potential. Reliability, diligence, trustworthiness and a vocational attitude are required. This quality of the individual is perhaps more important than what the educator tries to instill into him in the way of maximal knowledge. Although he should be above average, he should not be to such a degree that he will become discontented with his role in life.

## Functions

The function of auxiliaries is to practice empirical medicine. It is memory and limited skills applied within a defined area of work and to

an assessed limit of competency and to predetermined levels. As an assistant the auxiliary works as a sorting station or referral post. He needs to recognize and distinguish the minor departures from health from the major abnormalities. The minor illnesses are subject to routine treatment regimens which are determined by a central authority. Major ills and major problems, once they are recognized as such, are referred forward for more skilled attention. In addition, all auxiliaries should be able to apply first aid measures, for an indigenous population cannot always distinguish between one category of auxiliary and another.

In the role of substitute, the auxiliary has the additional functions of being required to undertake emergency medical care, emergency surgical care and emergency obstetrical care; and perhaps to initiate emergency anti-epidemic measures. The extent to which these emergency measures are permitted and taught depends upon the exact nature of the post, degree of isolation and facilities available. The substitute auxiliary has to be taught what to do when the physician is not present. It certainly means entrusting an auxiliary with modern therapeutic and dangerous drugs; to deprive him of these is to ensure that the ambulance becomes the hearse.

The medical assistant. Diseases can be divided into major and minor illnesses. The minor diseases are relatively straightforward to diagnose and simple to treat in the majority of cases. If one visits outpatient departments, health centers and dispensaries which cater directly to the public and analyzes the registers, it will soon be appreciated that a physician is not essential in 90 percent of the cases. In a sophisticated society much illness is self-diagnosed and self-medicated, whereas in an unsophisticated society, where there is both more illness and much more ignorance about what to do about it, there is a greater need for advice and help.

Ambulant diseases can be classified as follows. First the symptomatic diagnoses, such as headaches, sore throats, flatulence, dyspepsia, colds, neuralgias, rheumatism, myalgias, backaches, aches and pains, colic, constipation, diarrhea and the like. These are largely non-specific diagnoses requiring relatively simple non-harmful medication. Then there are the visible ailments—cuts, bruises, wounds, snake bites, tropical ulcers, scabies, impetigos, burns, conjunctivitis, running eyes, caries, goiters, and so forth. A third group are those which may be common in a local area and common knowledge to the population: malaria, anemia, tapeworm, roundworm, hookworm, elephantiasis, bilharzia, gonorrhea. These diseases are a little more difficult to diagnose but are not impossible for a medical assistant; they are susceptible to specific treatments. A fourth group are the well-known infant and toddler diseases—marasmus, kwashiorkor, whooping cough, measles, chicken pox and the like. The last group are suspect or re-

ferral diseases; they must of necessity be referred to more skilled hands for their diagnosis and treatment. This last group, however, comprise the minority of cases presented for treatment. (Paradoxically, simple diseases are not always simple to treat while some of the more serious diseases have an uncomplicated treatment.)

The training of a medical assistant should be related specifically to the minor and the common diseases in his local area. Treatment regimens must be devised on the basis not only of efficacy but also of their safety and ease of administration. For example, the treatment of malaria can be restricted to one given drug, say chloroquin, and instructions given that if a case does not respond within 48 hours then it is referred onwards; whether parenteral chloroquin is permitted depends upon the local situation. The medical assistant of the underprivileged countries is in fact a precursor of the "physicians' assistant" now being trained at Duke University, U.S.A. His job is the practice of simple empirical medicine in a limited range of diseases with restricted medicaments, to act as a sorting station, and to render emergency care. His responsibility is not the finesse of differential diagnosis which characterizes the modern physician, but the capacity for "visible diagnosis" and the recognition of major abnormalities as such.

The dental auxiliary. My observations lead me to believe that there is a great demand and need for dental services throughout the underprivileged countries. There is an even worse shortage of dental surgeons than of physicians, with distribution confined to the towns. In the adult there is a requirement for emergency and palliative measures: the relief of pain, extractions, periodontal care, abscesses and recognition of more serious oral pathology. In the child it is for early conservative work, simple cleaning and scaling, application of fluoride, treatment of gingivitis, simple cavity cleaning and repair, and instruction in oral hygiene. There are, of course, more serious needs of malocclusion and orthodontic work and the congenital abnormalities in both child and adult and oral cancer in the adult.

Many underprivileged countries have developed a school dental service but these are mostly limited to inspection. Few have trained dental auxiliaries to undertake oral operative procedures. I would train two types: one oriented to child dental care, mainly preventative, and simple repair work; the other to adult dental requirements of curative care and the recognition of serious oral pathology. I see no reason for such auxiliaries to receive prior nursing training. Such dental auxiliaries may be utilized in two ways—as chairside assistants or, after due experience, as independent working chairside operators.

The auxiliary midwife-pediatrician. Maternal and child care services are nowhere near saturation point in the underprivileged countries.

Outreach is normally between 5 and 30 percent of the population at best, yet the design of services follows that of the industrialized countries. With the same staff a greater outreach in services could be obtained by a revised approach.

The first objective of a maternal and child health program should be to detect the abnormal. Two antenatal visits, and two postnatal visits, one early and one late in each period would suffice in the majority of cases. The major abnormalities could then be referred to professional and paramedical personnel, while the auxiliary midwife could well be left to cope with the minor aspects of care and normal delivery. Childbirth is a natural process, and the limited obstetric beds should be restricted for priority cases: the frankly abnormal, the suspected abnormal, the primipara and grand-multiparae. What is lost in individual detection would be more than compensated for by the increased number of parturient women and newborn children being examined. Such a program would demand an alteration in training programs, emphasizing outreach rather than intensive care, as a first step in developing maternal and child health services.

In the preschool child much illness is of a minor or trivial nature, and many illnesses if attended to early would not progress to a more serious state. Marasmus, protein-calorie malnutrition, gastroenteritis, respiratory disease, malaria and the common infectious diseases account for much of the ill health. Sickness among the under-fives accounts for a high proportion of total sickness, the major part of outpatient care. In Senegal in 1962 of 550,183 outpatients aged under five seen by physicians, only 12,322 were admitted to hospitals; a further 463,352 were attended by auxiliaries on an outpatient basis. Diagnosis does not for the most part cause much difficulty, and could easily be made by specially trained auxiliaries. Treatment needs to be simple, effective, safe and economical.

A third point is that, under the conditions we are speaking about, excessive pregnancies prevented mean child deaths avoided. Much in family planning does not require a high degree of technical proficiency. I therefore advocate the training of an auxiliary midwife-pediatrician to screen, attend the normal births, provide family planning care, and take care of minor illnesses in the preschool child. What I have described so far is the "assistant" role; the auxiliary midwife-pediatrician in the substitute role must be trained to do whatever is possible when further obstetric and medical aid is not available. To withhold the right of giving injections, performing episiotomies, applying low forceps, removing a retained placenta, or giving intravenous transfusions is, in my opinion, unrealistic.

The junior health worker. Environmental health measures, vaccines, prophylactic drugs and residual insecticides have made a major con-

tribution to improving health, essentially through their defeat of the "filth diseases." It is these very diseases that still persist in the underprivileged countries, contributing so heavily to their morbidity and mortality. Yet environmental measures are not technically very difficult to apply in the rural areas. This means: improvement of indigenous housing, simple sanitary disposal (such as pit latrines, pour-latrines and aqua-privies), providing accessible and safe (not necessarily clean) water supplies (by wells, protected springs, gravity feeds, etc.), the inspection of meat or fish for one specific helminth (for example, cysticercosis or clonorchis), the drainage of waste waters, the disposal of garbage, the control of some vector borne diseases such as malaria and sleeping sickness, and the common infectious and contagious diseases. The research and the planning for these measures on a national basis are complicated and require professional competency, and the building of urban water supply and sewage disposal systems requires engineers; but the application of the simple measures that can be afforded at village level do not.

The laboratory auxiliary. Laboratory diagnostic work can be divided into the simple techniques and the more sophisticated requiring advanced technological skills and extensive biochemical and bacterial knowledge. The bulk of the work relates to examining stools for ova and blood; urine for albumin, sugar, blood and ova; sputa for tuberculosis and pyogenic bacteria; blood for parasites and counts. In essence laboratory work at district centers and health centers can be limited to microscopic morphology of bacteria and parasites, and blood counts. Bacterial culture, virology, histopathology, biochemistry and electrolytic work require more elaborate facilities and more highly trained personnel. Blood grouping techniques, however, should be taught at district hospital level.

The laboratory auxiliary for peripheral units must necessarily be a generalist not a specialist, since there is normally only one, or at most two. Public health laboratory work is almost unknown at village level and simple tests for water and milk could well be instigated. This knowledge and these skills can be acquired without the need for a university degree. Many laboratories in fact depend on trainees to carry out much of the simpler work. One can quite easily design a laboratory service that increases its range and depth of diagnostic procedures from rural health center level, to district hospital, to regional hospital and national central laboratories, provided there is an efficient postal system. The only way to improve epidemiological intelligence is to have peripheral laboratories throughout the health service, staffed by trained auxiliary personnel who perform routine laboratory procedures.

The pharmaceutical auxiliary. The advance of chemistry and biochemistry and the growth of the pharmaceutical industry with its mas-

sive range of proprietary medicines has rendered the individual compounding apothecary obsolete. Today he is virtually a retail storekeeper selling manufactured and carefully labeled products. In an organized medical and health service in a poor country one must necessarily limit the range of drugs available. This range may be designed on an ascending scale of liberality from dispensary to national hospital. There is obviously a place for a well-trained professional pharmacist at central and provincial levels, but the smaller units with well planned but limited pharmaceutical ranges need a storekeeper-cum-dispenser with much less training. The professional pharmacist at the regional or district hospital can be much better utilized than by handing out prescribed pills.

Nursing and radiography auxiliaries. The nursing auxiliary is well-known and accepted throughout the world. She is the "practical nurse" whose job it is to render patient comfort, patient observation, and drug administration as required at the smaller hospitals. The requirements for radiography in the distal units are mostly in connection with trauma and chest X-rays. Again such learning and skills can be acquired by much less intensive training than that required for a radiographer in a well-equipped radio diagnostic center. Equipment at health center level can be of simple push-button type, easily operated; the hazards of X-ray radiation with such modern machinery is often overstressed.

## Supervision

Five main reasons for the failure of auxiliaries to fulfill their role are, first, a failure of selection, and second, a failure to train for both the "assistant" and "substitute" roles. The third cause of failure is the sheer overload of work that requires the auxiliary to see patients much too rapidly—even for a professional to perform a good job. The fourth cause is that at times the auxiliary is called upon to exceed the limit of his training: this is the fault of the circumstances, not of the individual.

The fifth cause, the most important and most prevalent, is the failure of supervision. It is obvious in a two-tiered system, where there is a breakdown of a complicated job into simpler component parts, that supervision is all-important. Supervision includes disciplinary administration and the supportive and continuing in-service training. It is the latter that is most important, for by holding consultative clinics at regular times the auxiliary is encouraged and given more knowledge of what to do in the various situations that occur and which he finds beyond his competency. It is surprising how many trained professional people are unaware of the simplest elements of supervision, and of the art of working through others rather than attempting to do everything themselves.

## Basic Education and Technical Training

In recruiting auxiliaries, a basis of seven to nine years of school education will be the normal level from which trainees may be found. To accept students from primary school only will inevitably result in less efficient auxiliaries, trained in narrow fields. In some countries a surplus of high school graduates may be available. For students of middle school achievement, three years of initial technical training are required to produce a worthwhile auxiliary. For those who have completed high school, two years should suffice.

The objectives of technical training are to instill a limited basic theoretical knowledge on which may be grafted specific vocational skills. It is not to be confused with an abridged technical or university education; it is to train for a specifically defined area and level of competency. The requirement is to design a curriculum to minimal knowledge rather than maximal. Teaching must stress the ability to identify the minor deviations from health, to separate the minor problems from the major, and not to further define the major illnesses and major problems. The formation of a training program is dependent upon an accurate and well-defined analysis of the job to be done, and to train to specific job placement; this is contingent upon the organized services having a defined and precise place for the auxiliary. Thus, organized health services and training institutes for auxiliary personnel must be intimately coordinated.

Where the level of basic education is considered an insufficient foundation for technical instruction, then the necessary subjects, usually language and science, may be incorporated in the curriculum of technical education. The students' background will have led to the development of an auditory memory rather than a visual one; teaching must place greater reliance on the spoken word than the written, and not impose too much demand on literary abilities. Auxiliary students can rarely relate textbook to practice, and the teacher must attempt to do this for them. I advocate the so-called "sandwich method" of training, that is, alternating periods of theoretical instruction and practical application. This allows the consolidation of theoretical knowledge through practice, provided that the practice entails selected work problems, adequate time, the appropriate facilities, and intelligent and informed supervision. In the practical training of auxiliaries too much expediency has been practiced in regarding students as a cheap labor force to be occupied for the greater part of their time on menial tasks to the detriment of inculcating a student outlook and student status.

In designing a training program for auxiliaries, teachers must comprehend the basic distinction between training for the inexperienced "assistant" role and the experienced "substitute" role. Training for

auxiliaries must therefore be designed with the "sequence concept" predicated upon a certain minimal experience having been gained. One should no more expect a newly qualified auxiliary to fulfill the role of "substitute" than one would expect a newly qualified nurse to fulfill the role of matron.

Status

Many auxiliaries will have some kind of status problems, knowing they have failed to complete their schooling or achieve higher education. The position and value of the auxiliary is ill-understood, both in society and within the medical profession. Though he functions in a subordinate role, his contributions should not be underrated; the physician in the underprivileged country will hardly repay the cost of his training without the support of auxiliaries. Promotion prospects should be assured by recognizing the "substitute" role as senior to the assistant role and by making speciality roles available, such as health center supervisor, instructor, anesthetic assistant, ward supervisor and so forth. Retraining and further training courses should be linked to improved status and remuneration.

If a greater use of auxiliaries is accepted as a necessary concomitant of expanding health services, then it is desirable that their duties and responsibilities be defined, supported and protected by legislation. Medical auxiliaries should be governed through a medical auxiliaries council, constituted by statute. They themselves should have representation on such a council, and not be controlled through the separate councils of professional bodies; the interests are not always identical! Auxiliaries should be encouraged, not inhibited, from forming independent trade unions, and should not be lumped together with other unions where their separate identity is lost.

[Excerpted from "The Auxiliary in Medicine," Health Problems in Developing States: Proceedings of the Fourth Rehovoth Conference, 15-23 August, 1967, Moshe Prywes and A. Michael Davies editors. New York: Grune & Stratton, Inc. and Jerusalem: Israel Journal of Medical Sciences, 1968, pp. 294-304 and 307-308.]

# Book Review

Bryant, John, M.D., Health and the Developing World. Ithaca (New York) and London: Cornell University Press, 1969; 345 pp.

On the basis of a team survey of 21 countries in Asia, Africa and Latin America in 1964-67, sponsored by The Rockefeller Foundation, this book presents a searching examination of the many-sided problems faced by poor and relatively poor countries in supplying health services to their populations. The author exhibits an unusual feel for the human situations encountered, expressed in vivid descriptions of visits to a wide range of environments where limited facilities are used as best they can be, and in his appreciation of the various roles of participants in the delivery of health services and of conditions faced by those who would reform or improve them. At the same time he relates these insights to broader issues, and attempts to formulate policies which can be applied given the economic constraints, the organizational questions, and the basic causal and attitudinal factors involved.

He stresses the value of a health team—e.g., a doctor, a nurse, a medical auxiliary, a midwife, a sanitarian—working together to attack the health problems of a community or district. The team is a variable unit, to be combined as needed for the particular problems of an area, functioning usually as part of a governmental health service. Much of what he proposes is consistent with ideas enunciated in the preceding articles; he injects examples from experience in different countries, presenting suggestive illustrations rather than a firm or detailed outline of procedures.

Dr. Bryant's most profound examination is devoted to medical education. He points out that the advanced nations have exported a philosophy of medicine focusing on the high quality care of individual patients, and the less developed countries have accepted this and been proud to live up to it. But this philosophy has inadequate answers for the vast numbers of people not reached by excellence of individual care. Medical education neither motivates students to work apart from well equipped hospitals nor prepares them sufficiently to cope with the kinds of situations they would meet. Their

training is unnecessarily expensive, and often wasteful of time and effort in ways that contribute neither to "quality" nor to self-reliant operational capabilities in the students.

In general, Bryant would de-emphasize time spent in lectures, and in laboratories when the student follows prescribed activities, and would replace these with more student-initiated reading and lab experiments to find answers to problems. Even if fewer points were "covered" and memorized for examinations more would be remembered later, and student capabilities would be enhanced. He endorses the usual "clinical clerkship," where students participate in the care of hospital patients under doctors' supervision; he would extend this participatory method to experience in rural settings with limited facilities and a different kind of team relationship. Rather than just add a few lecture courses on public health to the medical curriculum, he would send students to the field to dig out facts about sanitation etc. in an area, analyze its health needs, and devise a "game" plan. He includes suggestions on how the training of physicians can be made less costly, and how other members of the health team can best be trained for their work.

The following condensed excerpt [pp. 57-61] gives some of the flavor of the author's style and subject matter. "The Ministry of Health provides the 3.9 million people of Malawi with 36 hospitals and 93 health centers. Most available money has gone to a few major hospitals. All health centers and most hospitals are operated by medical auxiliaries with little or no professional supervision. The reality of rural health care can be illustrated by a look at a regional hospital. As we approach it through the shimmering heat and dust, we see hundreds of "guardians" encamped around the grounds; they seem always in the way—on verandahs, in the aisles, even on the beds. Each looks after a relative who is a patient. The outpatient service is jammed with a pressing, murmuring throng. The smell of cooking smoke is strong. Two medical assistants are surrounded at their desks; some intangible feeling of sequence in the crowd tells each whose turn it is. Diagnoses are made at the simplest level in one or two minutes, based on the first words uttered by the patient. Cases that cannot be handled this way may be set aside for more examination, perhaps a simple lab test, and consultation with one of the more senior medical assistants. The two assistants see about 300 patients in a morning. [Examples of complaints and treatments.] There are heavy demands on the chief medical assistant in this 95 bed hospital with twice that number of occupants. He directs its functioning, makes most of the decisions on patient care, does all the surgery. He is an interesting and able man—trained in the 1940s, subsequently working sometimes under physicians and sometimes alone. He likes his work and is proud of it, though he speaks with deep feeling about the ways in which successive governments have handled medical assistants. As we leave, we think about the arguments for and against medical auxiliaries. This hospital serves one of the

most disease-ridden regions of Africa with only auxiliaries: it is likely that mistakes are made. How do these balance with the benefits? Should a man never trained for it do Caeserian sections? Perhaps this man can do them, but can the next man? For the women in obstructed labor, there is no alternative between a Caeserian and death."

## Trends in Mortality Rates

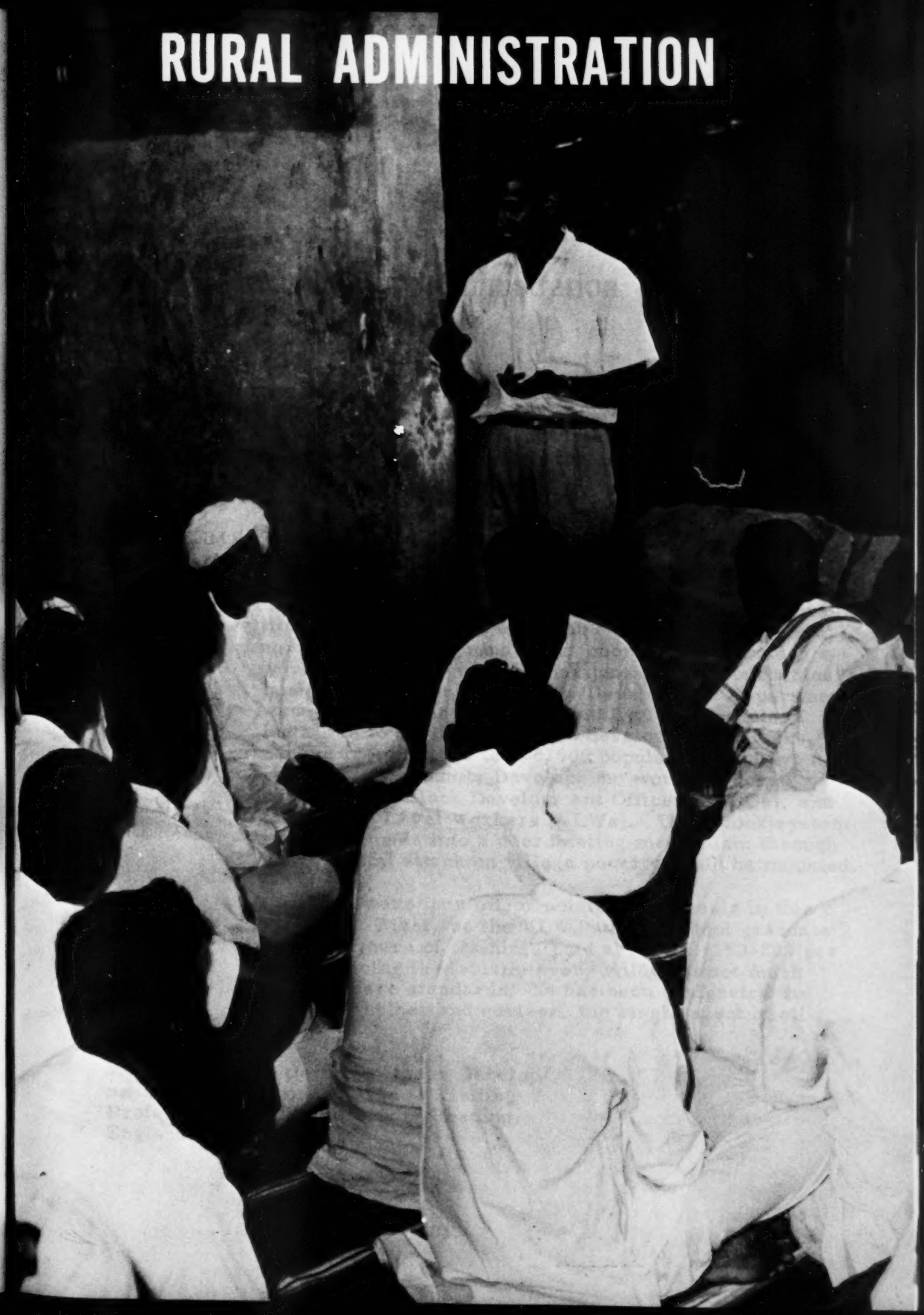
The most widely available measure of health conditions for comparing different areas and for seeing major shifts through time is the mortality rate, that is the number of deaths per year expressed as a rate per 1,000 of the population concerned. A summary view of the differences between regions of the world and the changes since 1937 is given below. The figures for Latin America, Asia and Africa are rough estimates, since these regions have countries where demographic information is weak. Nevertheless, it is clear that death rates have been going down very considerably in all areas except those where they were already low.

| | 1937 | 1955-59 | 1963-69 |
|---|---|---|---|
| North America | 11 | 9 | 9 |
| Oceania | 11 | 9 | 10 |
| Europe, excluding U.S.S.R. | 14 | 10 | 10 |
| U.S.S.R. | 18 | 8 | 7 |
| Latin America | 20-25 | 19 | 11 |
| Asia | 30-35 | 23 | 16 |
| Africa | 30-35 | 27 | 21 |
| World | 24-27 | 19 | 14 |

SOURCE: United Nations. For years before 1960: Population Bulletin of the United Nations No. 6, 1963. For 1963-69: Demographic Yearbook, 1969, p. 115.

Many developing countries have a distance to go before they reach the low rates in industrial countries. In 1906-10 the latter were higher: in northern Europe 14.1, southern Europe 21.7, eastern Europe 24.5, U.S. 16.2, Japan 20.9; the rate in Russia was 30.2 in 1913 (same source). Today most Latin American and some Asian countries have mortality rates around 10; rates in almost all countries outside Africa are below 20, usually well below, though few African rates are yet so low. Thus, there is no doubt that progress is occurring. But mortality rate comparisons among areas have a bias: populations with a large proportion of young people have lower rates, other things being equal. This bias favoring the younger populations in developing countries should be remembered, along with the probability that more infant and child deaths may escape the census takers in those countries.

# RURAL ADMINISTRATION



EXTENSION WORKER TALKING WITH FARMERS
IN HOSPET, NEAR BANGALORE, INDIA
[PHOTO: U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT]

# Lessons From India's Administration of Rural Development

Guy Hunter

[India has built up an elaborate system for bringing rural development to its vast population. The evolution of the system and the results of these many-sided efforts are of significant interest for other agricultural countries. In conclusion, proposals for an alternative approach are offered.]

The first great effort to tackle the uplift of the Indian rural masses in the early years of independence was based on a community development philosophy of broad-front attack on every aspect of village poverty—education, health, physical environment (roads, wells, etc.), agriculture, cottage industry, cooperatives, women's work, emancipation of the Harijans (the "untouchables"), land reform. The Community Development Department was given a great new responsibility. The whole of India was to be divided up into development "Blocks," each of from 60,000 to 100,000 population, and two new cadres of Community Development workers were created—the Block Development Officers (BDOs), and the Village Level Workers (VLWs). This Block system was to be made into a coordinating mechanism through which a total attack on village poverty could be mounted.

There were four major points of emphasis in this strategy. First, on the VLW, a high-school graduate with two years of training, paid about Rs. 150-200 per month, living in virtually every village at not much above village standards; he has been designated the farmers' helper and adviser, the single agent of all

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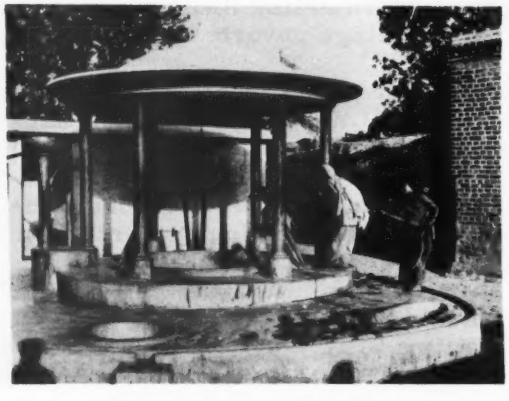
departmental programs which directly touched village life. Second, an emphasis on the administrative Block, where rather more expertise would be concentrated in the shape of Extension Officers of agriculture, health, education, cooperatives, water or road engineering, industries—all coordinated by a new figure, the BDO, to whom all services were made operationally responsible. This officer works under the Community Development or Panchayati Raj Department, though seconded from some other service; he occupies a key place in the whole system. Third, there was the higher and more powerful point of authority and coordination at District level (1-2 million population), under the immense prestige of the Deputy Commissioner (DC), the head of the District and leader of the District administrative team. Fourth, and in a different dimension, there was even greater emphasis on the creation of a system of popular participation by reorganizing, or shaping into a common form, the Village Panchayat or elected council; and by creating entirely new Block and District level councils in parallel to the administrative Blocks and Districts. The panchayat system, at three levels, was to concern itself very directly with development.

By a colossal demonstration of administrative energy, virtually the whole of India's population was brought within within this network of over 5,000 Blocks and 250,000 Village Panchayats in less than ten years. The main lines of the chain of command, reaching from state governments to the farmer, are shown in Figure 1; this diagram omits the specific methods of coordination at the state level and the complex relations of the states with the national government.

In the recollection of at least some administrative officers, the early period of building up "Panchayati Raj" (rule of elected councils) and Block development was exciting, and in some senses productive, though many others groaned under the muddles and waste of energy which often accompanied it. The Blocks were given funds, and they used them to build schools, village halls, paved village streets, and protected wells, all over India. The Village Level Workers were the agents of six or eight Departments, and they ran from the school garden to the voluntary road-gang, from the building of a covered bus-stop to the new compost pit, helping, reporting difficulties, and summoning aid.



Protected well built as Block project, Punjab.

But when the most glaring needs had been met, and when

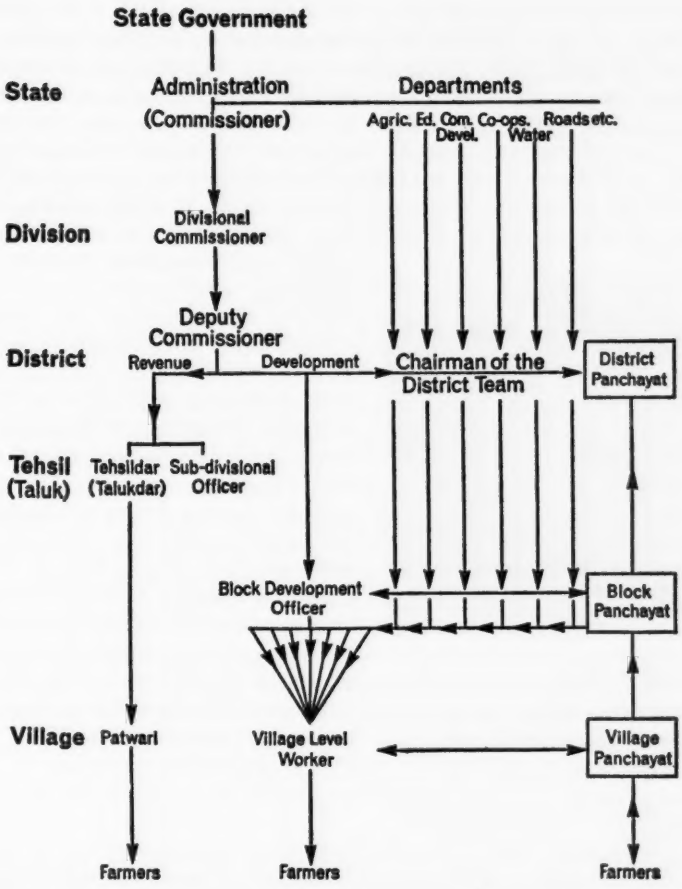



FIG. I

the early enthusiasm for voluntary effort began to run out, reports started to come in from all over India that the basic problem of village poverty was not being solved. Indeed, much useful improvement of the village environment had been achieved—though roads need maintenance and compost pits must continue to be filled. Perhaps best of all, a new image of government as a source of help had been partially created. But the production of wealth—and basically this means the production from the land—had not been greatly affected. The villages, partly by their own efforts, had cleaned themselves up a little, they had some new buildings, and (perhaps most important) they had a stronger means of self-expression through the panchayats and a nearer source of help in the VLWs and Blocks. But the scanty crops, the diet of rice or chapattis and a few green leaves, the indebtedness to money-

lenders, continued as before. In 1958/59, after a powerful Report to the Planning Commission, the emphasis was switched to production; 80 percent of the VLW's time was to be devoted to developing agriculture. The Intensive Agricultural District Program (IADP) was about to be launched; within another three years the new Philippine rice and Mexican wheat varieties, followed by substantial improvements in maize, sorghum, and millets, were to come into use. Perhaps from 1963/64 onwards the new production program began to gather impetus. It was held up in the drought years of 1966 and 1967, but sprang forward to the record harvests of 1968.

Farmers listen attentively to research worker explaining improved practices for growing Bajra (a millet).

Today, the overwhelming emphasis of the whole program is on production—though among a narrow sector of the "progressive" (i.e., mainly the larger, better-educated, and more influential) farmers in irrigated areas. But in terms of organization the period of Community Development and Panchayati Raj has left a continuing mark and the initial efforts have undoubtedly left an important legacy of receptivity to change. In some states the panchayats at Block level (at District Level in Maharashtra) have become powerful local government bodies with a wide range of functions.

## Coordination

The need for coordination in a rural development program seems clear enough. Increased output in the smallholder section in particular will need advice (backed by research) in crop and animal husbandry; a veterinary service; improved tools and equipment. It will need help with wells and pumps for minor irrigation, and the pumps will need electricity supply. It will need credit, and before it is creditworthy in commercial eyes. It will need an efficient distribution of seeds, fertilizer, and pest-control chemicals. It will need all this advice and service in a "package," i.e., at the right time, in the necessary sequence, and without internal conflict in advice or services among the responsible agencies. If the other rural development elements—education, health, village industries, clubs for women and young people, etc.—are thrown in as well, the task of coordination of agencies becomes formidable indeed. We have already mentioned subjects covered by more than half the Departments which a state government is likely to have—Agriculture, Veterinary, Water, Engineering, Communications, Power, Community Development, Health, Education,

Social Services, Finance, and District Administration. It is clear that these cannot be rolled up into one super-Ministry; it is clear that the point of unified advice and service must be the point which is as near as is practical to the farmer himself. But the all-purpose Village Level Worker cannot function if he gets conflicting instructions from the Block, nor the Block if there is confusion at District, nor the District if there is confusion in the State.

This is the traditional justification for the demand for more or better administrative coordination. But it is worthwhile to consider for a moment some implications of the concept itself. In the first place, coordination implies an antithesis to consumer choice. If there are plenty of goods and services on the market in wide variety, the consumer does all the necessary coordination by the process of selection and timing to suit his own purposes and his purse. To make consumer choice work there must be plenty—not shortages—on the supply side, and a certain level of competence, business sense, willingness to take technical advice, and independence or resources on the consumer side. Scarce resources in supply, and the ignorance, poverty, or dependence of the consumer, are at the roots of planning, state socialism, and "coordination." Secondly, coordination has a hostile ring to its victims, since it implies a loss of sovereignty; if the works chemist is to be coordinated with the works engineer by the works manager, both feel that they are losing an element of sovereignty (and in their own special field) and each suspects others of imperialism. The problem is worse where power is highly centralized and detail is decided at the top—the process of carrying this detail down a long hierarchy of command maximizes the possibilities of dispute and suspicion as well as the probability that local variations in need will be ignored.

Trouble is particularly certain in developing countries, which are characterized by shortage of resources—"shortage" is of course related to the ambitions of achievement; more modest ambitions automatically reduce it. They are also characterized by centralization of power. Finally, they are characterized by the ignorance and poverty of the consumer. It is because central government, in an agricultural development program, is endeavoring to do a great number of specific things to (or for) a mass of small producers who are assumed to be unable to do them autonomously, that coordination causes such constant anxiety and friction. The farmer is even given bags of fertilizer rather than the credit to use at his discretion. It is significant that the richer and more powerful farmers do not create such a problem of coordination; they make their own choice of what is available and buy it when they need it.

These very simple propositions suggest the main antidotes to the disease of coordination. A certain prudence in ambitions and maximum decentralization of detailed decisions will narrow the area where it

rages. A philosophy of enablement rather than provision or enforcement will simplify the task. In effect, the administrative problems of rural development should constantly decrease as the process succeeds. Good information to a farmer capable of understanding it, and at least a minimum range of choice to suit his needs, are the ultimate targets. But there is the question of timing. The belief that a good university pouring out extension information and a private sector for supplies, the combination which has worked in the U.S., are the right medicine for developing countries is wrong in present action simply because it is premature. If the problem is to uplift a mass of farming units which, in their present state, are not economically viable, through illiterate farmers who are indebted and socially or politically dependent, then a great deal has to be done executively and supplied artificially before the free economy can take over. It is this task which now faces developing countries.

## Administrative Problems

Planning and targets. The initial decisions on development must be based on what is technically possible within assumed financial limits, modified by what is humanly possible in farmer-response and staff performance. Apart from direct investment in land, water, and research, they will have to cover many external factors such as power supply to different areas and road services for access and off-take. They will also estimate the needed supply of fertilizers, chemicals, equipment, and trained personnel. All this will have to be related both to the domestic and to the export market. In cases of major new settlement or irrigation a mass of special factors such as housing, education, and health services, the economic return to farmers in the new scheme, and the training of farmers in a new agronomy will have to be assessed. Only then can the strength and geographical extent of the possible effort, both in investment and extension, be decided.

All this seems obvious, but it is partial neglect of this planning stage which has so often led to a series of emergencies and failures in agricultural development, some of which are wrongly attributed to failure by the Extension Service or to the obstinacy of farmers. These emergencies usually relate to shortages, e.g., shortages of fertilizer or spraying equipment for the new crop. Such failures arise either from bad central planning, or from failures in a single sector to meet what were reasonably planned deliveries, or from an overambitious program, which allows effort on a countrywide scale with resources equal only to two thirds of the country, or engages simultaneously on half a dozen schemes which all compete for the same administrative resources.

Planning seems to involve setting certain "targets" to be achieved over a certain time; on these targets will depend decisions, such as

a decision to increase fertilizer imports. But, in contrast to industrial projects, agriculture sets peculiar difficulties in the planner's way. It is not only that the weather can totally disrupt the program. Apart from those elements of the plan which government itself can control, the achievement of final results depends on the voluntary, unplannable choices and activities of millions of individual farmers. Professor V. M. Dandekar has driven home this point in some memorable phrases:

> Even in respect of the so-called physical programs, all targets are not equally meaningful. For instance, a plan target in major irrigation in the sense of creating a certain irrigation potential, has a clear meaning; but a plan target for minor irrigation, as it includes investment decisions of individual farmers in digging wells, etc., is not equally meaningful. Targets of production and import of chemical fertilizers are meaningful; but the targets of organic manures and green manuring are worse than fiction.... We witness the District and Block agricultural officers and the extension workers under them running around with targets of agricultural production, crop by crop, targets of areas to be sown with improved seed, targets of areas to be brought under new minor irrigation, targets of green manuring and targets of compost pits to be dug. In all these cases the officers know full well that what they can do in achieving these targets is extremely limited, and final decisions lie with the farmers....In consequence, a make-believe world is created in which targets are determined and progress reported in terms of items over which the parties concerned have no authority or control whatsoever. No one believes in these figures, and nevertheless everyone must engage himself in so much paperwork which is worse than wasteful—it is intellectually corrupting.

Despite many practical illustrations of the truth of Professor Dandekar's words, targetry does not stop. It has increased and is increasing; and it is easier to say that it ought to be diminished than to suggest the means. It is natural for planners to pretend they foresee the future, and it suits administrators to use targets as a measure of staff performance. The best that can be hoped is that planners will content themselves with estimates on subjects where government cannot control results; that state and District development organizations will be told how much finance they will get and what is the maximum supply of fertilizer (or power or tractors) likely to be available; and that targetry can be banned at the level of field extension staff, except where it springs from their own initiative and from local farmers.

It is worth mentioning here the antithesis to targetry embodied in the highly successful experiments made by the Shell Company in Italy, succeeded by similar projects in Nigeria, Thailand, Portugal, and

Venezuela. The essence of this approach lies in three factors. First, a very careful survey of the actual, local farming situation and its specific needs; second, almost total discretion given to the (graduate) Extension Officer to meet these needs, by technical advice related to the farm economics, the labor supply, the local market; third, higher technical advice and support to the Extension Officer when the problems are identified. There is, of course, a huge problem in extending these principles to a government service covering a whole country: what government would grant a local Extension Officer a year for survey and such discretion in action? Yet it is a situation towards which even government services should always be moving—an investment in the farmer's capacity to learn if the advice he gets matches his real situation. It is the extreme opposite of the central target and the national drive.

Extension Agents and VLWs. The old faithful crop varieties, with high toleration of conditions and of erratic weather, are most likely to be low-yield crops; new crops of better yield and quality are virtually certain to make more precise and imperative demands on the environment. For this, investment will be needed; for example, a secure source of water must be available for new crops of higher potential but higher susceptibility to water shortage. "Drives" and targets without such investment tend to produce premature decisions to adopt a more demanding pattern of crops before the right conditions have been really secured. In consequence, the high-yielding crop is grown with two waterings instead of the recommended four; or with 50 lbs. of nitrogen per acre instead of the recommended 120 lbs. to accord with the water supplied. It is these incomplete changes in agronomy which, in India, pull down the average field performance of a new variety from the 2,500-3,000 kilos per acre of which it is certainly capable in farm conditions, to the 1,200 kilos or less which will show up in the crop averages.

When more demanding crops are launched, the changes which farmers are supposed to make at a single stroke are seldom sufficiently allowed for. In areas where winter rain is scanty and uncertain, for example, the change from a single rainfed crop (followed by a low-value crop of pulses if there happens to be winter rain) to a double- or treble-cropping system under irrigation is enormous. It will probably involve accelerating harvesting procedures, to get one crop more quickly off the ground to make room for the next. It may well need extra labor, since watered and fertilized weeds grow faster, and harvesting and sowing must be quicker, and often harder work by the farmer in what used to be a slack season employed for visits and marriages. It will quite clearly mean more accurate and timely delivery of supplies of all kinds, and much more cash in hand, or credit in good time, to buy them.

It is one of the dangers of the "package" philosophy, involving several simultaneous changes in the farmer's methods, his credit position, his marketing, even his family arrangements, that the agency which urges him to change may not itself be capable of effecting the needed environmental changes smoothly nor giving the needed services punctually. It is the farmer who then pays the price for mistakes which are made by officials (or foreign advisers), and he is naturally not willing to risk too much. His experience of government efficiency is not, after all, so favorable. The package philosophy, when closely tied to high-yielding varieties, can also lead to a tacit assumption that the farmer's job is to grow certain crops on certain acreages as instructed by the extension agent. But it is not: it is to manage a farm, a whole entity (even if fragmented), from which he and his family must live. He must live every year, even while he is changing his methods.

The relationship of extension worker to farmer is a peculiar kind of teaching/learning situation, in which the teacher has certain kinds of information which could be useful to the learner, and has also (or should have) a method of analysis (farm accounts and economics of crops) which could also help him. The learner, on the other hand, has local experience, and experience of the task of management, and has this normally in a much higher degree than the teacher. The extension job is essentially to pass on information and to help with analysis; it is not to tell the farmer what to do. The information may be on a host of different subjects—sowing dates, the use of fertilizers, even prospective market prices; it may include demonstration of a method, but it has to be integrated into action and farm-management by the farmer himself. Partly because headquarters staff always think they know best what farmers should do, partly because the VLWs have very simple training, the tendency in India is to draw up a list of desirable practices and hand it to the VLW with instructions to persuade a maximum total of farmers to accept them.

It may be that the smaller extension staff in the old days had more time to give technical advice than they have today, when such a huge proportion of their time is spent on credit applications, fertilizer or seed distribution, or concocting a vast number of "farm plans" which are not always meaningful, and in any case are more helpful to the administrator than to the farmer, who knows every blade of grass on his farm already. We must think of this inflation of administrative as against technical work-load on the extension staff as a perhaps necessary cost of a program which seeks to raise the whole level both of technique and of cash investment for millions of farmers, not merely a few, in a very short time; but it is a real cost, and the sooner extension can get back to its real work, the better. Estimates of the time spent on technical advice differ; but some Directors of Agriculture said that up to 60 percent of the VLW's time was spent on credit, supply, and non-technical or community development work, despite the official policy that 80 percent of his time should be devoted to "agriculture."

The bureaucracy. Perhaps more attention would be paid to the problem of running a very large field force if the difficulties of the task were more openly recognized. An Indian state of 30 million population will have 3,000 to 4,000 VLWs in the field, almost evenly dispersed over about 20,000 villages, and another 2,000 officers only slightly less dispersed in about 300 Blocks. Many of the Blocks will not have a telephone, many of the villages are not even accessible except on foot or possibly on a bicycle from the nearest hard road. The staff are, of necessity, poorly paid; at VLW level they are often considerably dependent on the goodwill of the richer or more powerful members of their village. Their prospects are not good: while obvious failure may be penalized, there is little material reward for good work under hot and trying conditions. Very much the same could be said of the lowest ranks of extension staff in other countries of Asia and Africa.

Something could indeed be done to improve career prospects and rewards for effort: at least salary increments could be increased, since the social cost (in a technical sense) of employing otherwise unemployed young men, in whom a 10-year educational investment has been made, is very low. But the problem of supervision and of service to staff is harder to solve. Targetry, and much writing of diaries, reports, and records are heavily used in India as a means of supervision; it is a bad one. The VLW or Extension Officer anxious to improve his record and achieve his targets will certainly be tempted to persuade farmers to plant crops they cannot afford to cultivate properly, to accept credit they are unlikely to repay, and to adopt methods which do not suit their land. This will be true even if he resists the temptation to falsify reports, or, indeed, to accept tactful gifts in cash or kind from those seeking subsidies or licenses or other favors available through the government machine. In addition, the difficulty of servicing this dispersed force is also great. The seed or fertilizer they are supposed to distribute arrives late (one Evaluation Report mentions a case where VLWs were told to sell late seed for what price they could get and carry the loss from their own pockets). They may be told to distribute a variety of plant which is wiped out by disease; the new seed-drill which they are told to popularize may prove ineffective in farm conditions. There are many reasons beyond the extension man's control why his program is frustrated, and this diminishes his standing with the farmer and spoils his target performance. It is no wonder that some become first fatalistic and then lazy—the remarkable fact is that so many keep up their effort year after year.

There are no simple answers but there are ways of diminishing this problem. Career structure, pay, and training are one. Another may well be to restructure the service, wherever possible, so that the lowest grade of extension officer is employed by the farmers whom he serves—a cooperative, a village panchayat, or a farmers' association. There are difficulties here: the biggest farmers will tend to get most

service and local jealousies or vested interests may play too big a part. But the advantages would be great—those who pay the officer would be keen to see that he earned his keep and much more able to judge his work. An alternative system would be to stop the government chain of command at the Block and to use VLWs under village panchayat control, but with government training, roughly on the analogy of the "animateurs" in Francophone Africa. Other possible improvements would be to substitute tasks for targets, to see that the officer is fairly frequently brought to meetings with his colleagues, and to ensure that he has a chance to talk over his problems with them and with his supervisors.

Another improvement would be to give the VLW a less impossible task in terms of the number of farmers he is supposed to look after and the number of masters he is supposed to serve. It could well be argued that the number of VLWs should be further increased; 10 VLWs to 1 Agricultural Extension Officer looks a reasonable proportion. But at the Block level there are other officers using the VLW constantly—the BDO himself, the family planning organization, the cooperative, education, irrigation, and animal husbandry staff, the panchayat officer. This strongly suggests that there are too many masters to too few VLWs. If one VLW was 100 percent agricultural, including irrigation and animal husbandry, and an additional VLW was wholly "social" (education, nutrition, family planning, rural manpower, etc.), the supervisor/worker ratio would be better and certainly the Agricultural Department would be much better served. The training costs of VLWs are low—about Rs. 500 (less than $70) per man per year on a two-year course is the figure given independently in four different states; the manpower available is enormous.

Apart from the morale and efficiency of the field staff in direct contact with the farmer, the second and even harder administrative problem is to achieve some technical coordination of their efforts. The main reason for putting the BDO in operational charge of all Departmental officers at his level is to provide leadership, direction, and responsibility by a definite allocation of authority. It is clear that where eight or ten extension staff share a headquarters and an area, someone must be at least their chairman; and that some one officer must be the secretary and senior executive for the Block panchayat. It may, however, be possible to modify the degree of control he can exercise over technical staff in the development Departments. There is a considerable uneasiness in the Agricultural Departments about this assigning of authority to a non-specialist, moderately expressed but widespread; and it will tend to grow as agriculture becomes more sophisticated and technically demanding. But while technical collaboration rather than authoritarian coordination is the desirable long-run aim, it would be very unwise to underestimate the urgent need for some cure for the constant muddles which occur in the present Indian system at all levels. Some examples from a 1964 report:

> In Meerut and Rampur it is stipulated that 20 percent of the cooperative loan should be given in the shape of fertilizers. The Department Commissioner issued a circular to this effect. ... Almost simultaneously... the Registrar of Cooperative Societies issued another circular saying that loans in kind cannot be imposed on the Societies as these are autonomous public bodies.... The BDO [Chamrahuwa Block] did not allow the Block staff any leave in Dussehra and Diwali holidays, as these were the peak period for the distribution of fertilizers for the rabi crop. But the cooperative supervisors closed their warehouses during this period.... etc.

It must be added that these instances related to a time when the production program was still young. Some of these difficulties have since been ironed out, but it is almost impossible to work the complex organization in its present shape.

One lesson for other countries is partly one of timing: full authority may be needed at first to establish the necessity of coordination; but it can probably be modified into technical collaboration, under a chairman rather than a boss, when the system and its inherent necessities are familiar and understood. It is certainly worthwhile to record that, in good Blocks, the sense of team-spirit and common effort among the Block team—all young men, mostly in their 30s—was very evident and very encouraging; there is something of real value here whichshould not be lost. But the greater lesson lies in reorganizing and simplifying the system.

Supplies, credit, selling. It is because the small farmer is economically weak, and because the supply of goods and services which he needs is scanty in a poor country, that so much of the time and effort of extension is taken up in handling supplies of seeds, fertilizers, sprays, and credit, and in endeavoring to ensure a fair market for farm produce. The farmer with no telephone, an ox-cart in which it will take a whole day to go 7 miles to market and back, and little or no ready money in his pocket, is simply not capable of commercial farming in a modern sense unless supplies and services and credit are brought virtually to his door. Without them he will use seed from last year's crop, borrow from relatives or at 36 percent or more from a moneylender if he must, use only what compost he has for his crop, and sell in the harvest glut to the merchant at the farm gate. If one day his country grew richer, things would perhaps be better. It is the stage of general poverty which is the trouble. Meanwhile, some help is needed; and the real choice is between help from a government bureaucracy and help from more powerful neighbors, on their terms.

At first sight this seems to leave out the obvious solution—cooperatives, formed and managed by small farmers. But in India at

least this will largely come back either to the second choice—powerful neighbors—or to failure. Several studies of cooperatives in India, and common observation in the field, confirm that a major part of the cooperative movement, both in India and in Pakistan, is dominated by the big farmers, businessmen, village magnates, ambitious chairmen of Block Panchayats, and the like. Some of the "big men" cooperatives are highly successful; in some of them even the small man gets many benefits for which he is thankful. Some of the older cooperatives provide an excellent tool for the new programs, and have a wide range of membership; but such successes with wide social coverage are rare. Mainly the system works in favor of the big men. They have the opportunity: they provide the leadership, and they reap their reward. The huge extent of cooperation in India—nearly a quarter million societies and over 25 million members—is in itself an organizational feat and may have educative and civic values quite outside commercial success or failure. But numbers certainly do not imply efficiency. There are some notable, even brilliant, achievements mainly in three or four states, but elsewhere not more than half the societies are viable, and a much smaller proportion are really successful. Almost always, those that succeed best are dominated by a few rich men. In a democratic India in 1969 this is the subject of much uneasy comment.

It is possible to try to modify this state of affairs by injecting a good deal of bureaucratic control of cooperatives through a Department and its extension officers. But, on balance, the result is to get more of the worst than of the best of both worlds. The bureaucratic element carries its own characteristic rigidity with it, providing inspection rather than management skill. It does not in fact prevent domination by the powerful, though it may reduce their efficiency by interference. India has very often fallen into this trap. The evaluation reports are full of the guerrilla warfare, or lack of cooperative action, which goes on between Agricultural Extension staff and cooperatives. Yet the basis of so many schemes assumes intimate and highly complex forms of common, coordinated action between them. The whole credit scheme for the high-yielding varieties program is based on assessment and identification of needs by the VLW or agricultural staff which is to be matched in great detail by the issue of crop loans through the credit societies; more than half of the "package" really depends on cooperative efficiency. Yet there is widespread complaint that the cooperative system is the weak link which constantly breaks.

This is an unfortunate situation, and it has its parallel in many countries, in both Asia and Africa. The problem can be narrowed a little. There are three sets of circumstances where there is a reasonable chance of success, and three with a high probability of failure. A cooperative of growers of a single cash-crop, closely linked to a processing plant—sugar factory, tea factory, cotton gin, etc.—has a good chance of success. A cooperative which is marketing an export

crop through a central procurement and marketing board, such as the Lint and Seed Marketing Board for cotton in Tanzania, is often viable. A cooperative, often less formally organized as an irrigation society or a farmers' association, which uses some physical facility in common—a tubewell, store, dairy, rice mill, etc.—may be highly successful, particularly on a small scale. The least successful cooperatives seem to be pure credit societies; societies which attempt to market internally-consumed unprocessed crops in competition with private merchants; and cooperatives used as a distribution system for inputs and credit, especially where they have no hand in planning the production program and little share in marketing the crop—a situation which constantly occurs in India and many other parts of the world.

If these conclusions are roughly correct, the implications are: 1) not to use pure credit societies—their turnover and profit margin are too small; the credit function works best as a by-product of a successful production and marketing or processing operation, not only because margins are higher but because there are real savings by members, which are by far the best basis for credit; 2) not to force cooperative marketing of internally-consumed crops where there is merchant competition; 3) not to force people into cooperatives by grants of a monopoly of either credit or supply. If acute shortage of supply exists, a government rationing system, direct to the citizen, is less dangerous than rationing through societies. Forced membership means a majority of members who join simply to get access to rationed supplies or subsidies, who have no interest in the cooperative as such, and who will desert or even cheat it if it suits them. Perhaps the commonest of all worries in India is the member who accepts fertilizer or seed from the cooperative, sells his crop to the merchant, uses the cash to repay old debts or marry off his daughter, and defaults on repayment to the society. As to marketing, the plain fact is in India—and more widely throughout Asia—that the farmer so often finds more reasons to sell privately than through his cooperative.

This is not a prophecy of unrelieved gloom. If the farmer's crop is doubled or trebled by better methods and varieties, he can clear his indebtedness and meet the merchant on more even terms; and the cooperative itself will have more chance to compete if it is composed of prosperous and competent members. Unbroken poverty is the real root of the trouble, and that must be cured on the production side, and by the growth of a far better understanding of how a commercial economy works. Cooperatives are far more likely to succeed in the second stage of growing prosperity than in the first stage of weakness; and they are not necessarily or even probably the prime agent for achieving the move from weakness to strength.

National economics and farm economics. All sorts of factors influence national agricultural policy—food shortages, shortage of foreign

exchange, international marketing quotas, and many more. At the other extreme of the scale, all sorts of factors influence the farmer—his farm income, the level of work required to make it, and his security. In India the national issues tend to dominate thinking so much that the economics of the individual farm have been seriously neglected. "Drives" and targets tend to spring from national policy, and fall on suitable and unsuitable soil indiscriminately. As examples, national price policies of cheap food for urban consumers defeat crop policies in agriculture; drives to plant sisal for export on a falling market impoverish the farmers who agree to it; etc.

Unluckily, the actual analysis of farm economics, complicated as it is by social factors and traditions, is extremely difficult. The attempt to analyze the multiple choices and constraints of an individual farmer ends up in highly sophisticated linear programming, which is certainly beyond the competence of the average extension worker. It is also, unfortunately, very local: a single recipe cannot be worked out at state headquarters where an adequate team of economists could be mustered. Meanwhile, the extension service, with its average staffing, must work by simpler methods which can be widely taught and used. There is a slow increase of emphasis on "Farm Management" as a study to be included, and stressed, in the initial training courses for extension staff and in some cases in refresher courses for existing field staff. This could be regarded as a "lumpy" subject—i.e., one in which, unless the full analytical method is taught, the halfway house of common sense and simple arithmetic will not be useful and may be dangerous. It is important for the progress of agriculture, for the next decade at least, that this view should not prevail. There are, in fact, large opportunities for increasing farm incomes by common-sense analysis, although the increase may fall well below the full theoretical maximum. The point now is to imbue extension staff with a far stronger feeling that farm income, rather than production alone, is their target; and to give, both to extension and to farmers themselves, at least some simple aids and tools of thought in approaching this problem. The very difference between successful and unsuccessful farmers who face similar problems is an indication that one is, even subconsciously, solving his equations better than the other. The Indian farmer of middling ability and education appears to be more conscious of farm incomes and expenditures than the comparable African—at least in East and Central Africa. To make this process even a little more conscious and methodical, and to emphasize it as central to the extension process, could now be important.

## Suggestions and Conclusions

Social philosophy. It has been assumed that a government will aim at some degree of social equality, at least in income distribution. This is both a moral issue and a practical question. On practical grounds,

it can be argued that the most speedy route to equality is to start by backing the relatively rich and enterprising, who will be most capable of generating economic growth, later to be diffused either through impersonal economic forces or by conscious social policy. The opposite point of view, too, has both a moral and a practical dimension. The practical grounds here will be a prophecy that to increase inequality, if only temporarily, will lead to political upheavals so violent as to halt economic growth, or at least to destroy the present holders of power. There are also respectable economic arguments that more equal income distribution would accelerate growth in some developing countries.

This issue can be brought down from the realm of general argument: for example, it has been assumed here that it is a "bad" thing for cooperatives to be too completely dominated by the bigger and richer farmers and merchants; and this is consistent with Indian policy, which has so far been professedly egalitarian. But it could well be argued that, in the transition to a commercial economy, some men—a minority—are bound to emerge with more vision or energy or cunning than others, or simply a privileged start in the race, and that this emergence is inevitable in one form or another; if they do not appear through cooperatives, they will appear as dominants in a party hierarchy, or in any sphere where the rewards—whether of money or power—are tempting. In a study of cooperation in Tanzania by J. S. Saul, cooperatives are shown to have offered an opportunity for corruption and personal gain in power and money to the "activists" who first emerged from the traditional society. Thus the very vehicle of socialist advance favored by the Tanzanian Government as an alternative to capitalism and greedy middlemen is in danger of turning into a vehicle of inequality and even exploitation by producers.

It is impossible to suggest solutions, but it is perhaps desirable to indicate the assumptions on which this study rests. They are, in brief, that in each succeeding stage of social growth human energy will break through the current norms into types of behavior which carry both possibilities of economic and technical advance and possibilities of unacceptable injustice and abuse. The moral discipline has to be evolved along with these changes, in ways appropriate to each stage of growth; too much may lead to stagnation, too little to revolution. In practical application, if we continue the example from cooperatives, there are parts of India where any genuine share of control by small men is virtually impossible, partly from general ignorance and poverty but also because the big men have so many strings to their bow of domination—caste, land ownership, their position as both creditors and political bosses. In such cases the institution of cooperation may not even be progressive; "new men" will never get a chance to emerge. There are other areas where prosperity and commercial knowledge are more widely spread, where cooperatives

may actually foster the emergence of new energies in new classes; in these a modicum of discipline and of special attention to the weaker elements may be all that is needed to secure both growth and at least a reasonable degree of social justice. A parallel argument applies to elected local councils. The point of criticism is not directed against the big men as such—many are young and progressive, many practice the best kind of paternalism—but against the lack of opportunity for small men. In Indian agricultural development over the last ten years the rewards have gone mostly to the strong; there has been some dramatic growth and some dramatic inequality. In "socialist" Africa there has been a tendency to put on the brakes of moral discipline before growth achieved any momentum.

Investment and research. Good agriculture in a temperate zone—in England or France—looks so "natural" to the layman that the huge investment which has been made in those cornfields and pastures and wandering roads is easy to forget, partly because it is not obtrusive, partly because it has been done over so many centuries—drainage, levelling, river training, power supply, access, shelter, storage, and behind it all a large engineering and chemical industry. In developing countries the concept of investment has been perhaps unduly concentrated on dramatic schemes of major irrigation or forest clearance. At some stage this control of the environment has to be achieved; but along with these major attacks on the environment, a host of smaller investments and skills are needed, which will one day give the "natural" look to a high level of farming. If there is one thing that the Indian experience has underlined, it is that agricultural advance has owed more to investment than to organization or propaganda or literacy or cooperatives or community development. The two critical investments have been in water supply and crop research, applied to a skilled tradition of farming. All the other factors—they are necessary factors—have followed on these, and without these the rest have been very largely ineffective. In tropical Africa land clearance, an earlier stage, is as important as water supply in many areas.

Water supply, in agricultural terms, is an expensive business, even when major irrigation is not involved. Geological, hydrological, and soil survey are necessary if the job is to be done properly. Research is also costly, when all its stages are counted in—fundamental work in plant-breeding, followed by agronomy, local testing, rebreeding for local conditions, developing an economic regime of fertilization, pest-control, sowing dates, water management, and so on, and followed again by staff training and farmer training. Extension comes very late in this sequence, with all the organizational and other problems which go with it; and success in extension depends on the prior investment. There are, indeed, some places where existing knowledge and proven practices can be extended far more widely; there are places where a social change—land use in particular—can achieve dramatic results.

But in those areas, and they are probably the largest, where the effort to improve agriculture has been applied for many decades without notable success, something new has to be done, in physical investment or research or both together, before results are likely. If in India the Extension Service has often been frustrated by failures in organization or supply or marketing, nevertheless the lack of investment and research is, over millions of acres, much more significant. Quite a lot of the agricultural budget in extension salaries and administration is thrown away in keeping a staff hammering vainly at a door of agricultural advance which can only be unlocked by these two factors.

The agencies. Where the appropriateness of effort, its scale, and its timing have been decided, and when the investment program has been planned, the question of agencies to effect change comes next. This is essentially a social problem, and the critical issue is therefore that of appropriateness to the existing society. Agriculture in developed countries is essentially self-running save for the price mechanism (which is usually much regulated) along with an important research input from government and universities. But in developing countries the whole environment of plentiful services and choices does not exist—this is almost a definition of their situation. Thus the choice of agency to provide it, in gradually increasing volume, becomes critical. Most critical of all is the precise definition of the stage of development which a particular economy, and particular regions and districts of that economy, have reached.

It becomes important to ask if IADP, the intensive concentration of resources on selected districts with high growth potential, is the appropriate program for the conditions. This program, started in the early 1960s and gaining momentum with the new high-yielding seeds since 1967, is dominating India's current rural development efforts and thinking. In 15 favored Districts (out of 325 in all) the VLWs per Block are doubled and the Agricultural Extension Officers quadrupled; in 120 more Districts one half of this increase is provided. Looking at its successes and weaknesses [evaluation omitted], one may see the results of a program which relies on a bureaucracy to manage the multifarious problem of quick and accurate supply and support, and the bureaucracy almost inevitably ties itself in more and more complex knots in the attempt to do it. It is natural that its successes are greater among those farmers who can, in effect, exert an exceptional command over the scanty services available; who can afford to stock up with materials, who can reach a telephone or bully an official to organize supply. It succeeds with the small village farmer only where there is extraordinary and constantly renewed effort and persistence by an administration fighting its way through the cat's-cradle of its own systems.

Much the same situation applies to cooperative action, as noted above. The provision of credit also leads to the same kind of argument.

Most backward small farmers are intrinsically uncreditworthy, partly because their whole income and cash position is shaky and unsound as a family unit, and partly because the way in which they apply credit seldom produces the net gain in earnings which allows both for profit and repayment. Credit applied by a larger unit—such as a sugar company—means that the crop decision and the profitability calculation is made by a competent body, and recovery is made on a scale large enough to cover a small proportion of failures. Since nearly all government-backed credit schemes to small farmers lose quite a lot of money, it might be better to spend the money on a competent management unit for as long as was necessary to get it onto its feet.

The argument is pointing more and more to a need for competent leadership and management of groups of farmers, on a quite local scale but big enough in acreage and turnover to justify the management cost. It is reinforced by experience which has not been sufficiently heeded—the experience of voluntary agencies who have set themselves to improve farming. There are literally hundreds of such examples in developing countries—missions, schools, nutrition projects, relief and settlement schemes. Characteristically, the successful agency gains the confidence of local farmers, bringing them technical advice and help both in growing and selling their crop. Almost invariably the result is a marked step forward in agricultural productivity, often well ahead of neighboring areas where the regular government Extension Service is functioning. The virtues of these projects seem to lie in their flexible adaptation to local needs: the fact that they are not forced into a national pattern either of production policy or of organization; and that their funds, though usually meager, are freely disposable at the discretion of the local unit. Their weakness may lie in the technical training of their staff, but it is largely compensated by the ability to call on technical advice if it is needed. Similarities to the Shell Company projects may be noted.

It is obvious that voluntary agencies cannot undertake even a fiftieth part of the total task of extension work for small farmers. What seems to be needed is a marriage between leadership, technical information, and good management on the official side, and various types of informal or "pre-cooperative" activity on the farmers' side. Would it, for example, be possible, in the Indian case, to reorganize the Block so as to include an "Agricultural Service Unit" which would offer—not demand—to take over certain types of common management functions for any sizable group of farmers which voluntarily agreed to such a scheme, with some form of representative consultation between the farmers and the Unit? Such a scheme would certainly involve numerical strengthening of extension staff (which is in any case necessary) and also a new element in training staff in these more managerial functions. On the farmers' side, the formation of a local "Farmers' Association," with objects and rules appropriate to the local scheme, would provide all the structure needed in the early stages.

Such a system may seem very like a cooperative. But it differs in two vital ways. First, the management of the supply, technical advice, and primary marketing system would be provided by a reorganized and strengthened extension unit, with a chain of higher technical and administrative reinforcement on call to it, in the form of the normal District staff. Secondly, it might be unnecessary to give individual issues of crop-season credit—the standard costs of seed, spray, or fertilizer would be deducted at the harvest stage when the crop comes in. Credit for development of individual farms would need separate handling, and would be subject to management approval and supervision if it came through official sources; farmers could, of course, be free to borrow privately for their own farm improvement. Larger works—soil conservation, irrigation for a group, etc.—could be treated, not as credit, but as government investment, partly recoverable by a water rate or similar charge.

Such a system would have an opportunity to develop in one of three directions. First, into a normal cooperative, if the farmers' committee felt that they could do better than the official management; in that case, the first stage would be a "guided cooperative" or "pre-cooperative." Alternatively, into larger Agricultural Service Units. Finally, if the system became unnecessary as farmers became more sophisticated, incomes rose, and private suppliers became keen to move in, it could fade away and allow a reversion to purely individual farming, with a relic of such common services as might still be valued. Obviously, great care would have to be taken to see that management costs were reasonably related to turnover, not forgetting that at present the Extension Service is provided free to farmers and is, in fact, a management cost borne by government but without either the power or the training to manage in this sense.

There are quite a few systems which approximate to this pattern, and it would need careful formulation and adaptation to local circumstances. The Kenya Tea Development Authority manages its thousands of small growers in much this way—the farmers remain individuals growing their own food or other crops but the tea crop is centrally managed. The Federal Land Development Authority in Malaya runs a plantation system (rubber and palm oil) through individual "settlers" who will one day become beneficial owners. The Gezira cotton scheme in the Sudan was partly so managed, and there are similarities with the East African tobacco system. Most of these, however, dealt primarily with a single commercial crop; such systems have not yet (to my knowledge) been widely applied to an area of mixed subsistence and cash-cropping on small holdings, nor organized by a variation in the normal administrative system. The World Bank scheme near Lilongwe in Malawi is perhaps close to this method. The Comilla system in East Pakistan is near to it in that the "manager" of each small Primary Cooperative is in constant touch with the Academy, and the management

of the Thana-level Cooperative Union is strongly staffed and again closely watched and supported from the official side.

These examples are not put forward as a blueprint for immediate application. They are simply to illustrate, in the roughest form, certain things which need to be faced and certain indications of a route to success which appears to satisfy the necessary conditions. The main propositions are as follows:

1. That the attempt to service millions of small farmers individually through an extension service containing several departmental interests but without management responsibility, delivering a complex "package" and individual cash credits, is barely feasible. It is expensive in unrecovered credit and overcomplex in administrative coordination. It is likely to end up in servicing only the larger farmers who can make the system work to their advantage.

2. That the attempt to cure this by independent cooperatives of small farmers without strengthening and supporting the cooperative management is not only likely to fail (except where the same large farmers capture and manage it) but further complicates the administrative task by introducing an unreliable and semi-autonomous element into an already complex and confused official structure.

3. That in some areas there is little hope of advance unless someone is willing to assume management responsibility for a considerable acreage and number of farmers. In the early stages, and where this cannot easily be done by company management of a single commercial crop, it may be worth reorganizing the government service much more directly into management units for basic supply, technical service, and primary marketing, possibly abolishing the individual crop-credit system. This would require reorganization and some strengthening and retraining of the extension staff.

4. That this would provide a stimulus and an open-ended structure which could develop later into standard cooperatives, or into larger service units, or could revert to a much strengthened individual system.

Save in those countries which have a rooted objection to private enterprise as such, private firms should be able to play an increasing, and finally a dominant part in the business side of agriculture, selling fertilizer, hand and power tools, pumps, building materials, repair and maintenance services; buying and handling produce from the primary groups; providing short-term credit to reliable customers; and seizing opportunities for processing and minor industry in the rural area as they arise. This is a stage still some way ahead in India and some other Asian countries, even further ahead in Africa. It will not be reached until the farmers' purchasing power and financial stability

is much greater. But when it does come, it will immensely relieve and simplify the burden on government services, and will introduce a flexibility into farm management and agri-business which, in the nature of things, government will always find it hard to achieve.

[Adapted from The Administration of Agricultural Development: Lessons from India. London: Oxford University Press, 1970, pp. 24-30, 61-83, and 127-140. ]

[EDITOR'S NOTE: The major topics in the original book that were omitted here are: detailed account of the workings of the administrative structure; evaluation of IADP; analysis of the forms and contributions of panchayats.]

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